ALSTOM

ACCUTRACK PRODUCT SOLUTIONS

VPI®

Vital Processor Interlocking Control System

Product Overview

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WARNING

Read and understand this manual before using this equipment.

Failure to follow the instructions presented in this manual can degrade the safety performance of the train control system resulting in property damage, injury, and/or death due to train collision or derailment.

Product Overview Manual
P2086G

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Alstom Signaling Inc.
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PREFACE

NOTICE OF CONFIDENTIAL INFORMATION

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B	May 2003				
C	March 2004				
D	November 2013	Updated to include new warnings.	SG	KW	MS
E	January 2015	Updated for clarity; added additional warnings; added Safety Warnings section	SG	KW	MS

ABOUT THE MANUAL

This manual introduces the Alstom Vital Processor Interlocking Control System (VPI®).

The information in this manual is arranged into sections. The title and a brief description of each section follow:

Section 1 – SAFETY WARNINGS: This section contains the safety information presented as warnings applicable to the VPI system.

Section 2 – INTRODUCTION: This section describes the manual organization, introduces the topics enclosed, and provides a glossary of terms used in this manual.

Section 3 – VPI: This section gives general information on function and organization of the VPI system.

Section 4 – CHASSIS CONFIGURATIONS: This section describes the chassis used for the VPI system.

Section 5 – VITAL SUBSYSTEM: This section describes the Vital boards and assemblies used in the VPI system.

Section 6 – NON VITAL SUBSYSTEM: This section describes the non -vital boards and assemblies used in the VPI system.

Section 7 – DESIGN, TEST AND VALIDATION TOOLS: This section describes the design, test and validation tools used for the VPI system.

Section 8 – NON-VITAL SYSTEM AND COMMUNICATIONS SOFTWARE: This section describes the non -vital system and communications software used in the VPI system.

MANUAL SPECIAL NOTATIONS

In the Alstom manuals, three methods are used to convey special informational notations. These notations are warnings, cautions, and notes. Both warnings and cautions are readily noticeable by boldface type and a box around the entire informational statement.

Warning

A warning is the most important notation to heed. A warning is used to tell the reader that special attention needs to be paid to the message because if the instructions or advice is not followed when working on the equipment then the result could be either serious harm or death. The sudden, unexpected operation of a switch machine, for example, or the technician contacting the third rail could lead to injury and/or death. An example of a typical warning notice follows:

WARNING

DISCONNECT MOTOR ENERGY

Disconnect the motor energy whenever the gear cover is removed. Otherwise, the switch machine may operate unexpectedly and can cause injury and/or death.

Caution

A caution statement is used when failure to follow the recommended procedure could result in loss or alteration of data. A typical caution found in a manual is as follows:

CAUTION

Changing session date and time to earlier values may affect the ability of the History Window to store data correctly.

Note

A note is normally used to provide minor additional information to the reader to explain the reason for a given step in a test procedure or to just provide a background detail. An example of the use of a note follows:

Note: This step should be done first to validate the correct information is used.

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SECTION 1 – SAFETY WARNINGS

1.1 SAFETY WARNING MATRIX

Warnings are presented in Table 1–1 for convenience in locating an applicable warning.

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1.2 SAFETY WARNINGS

WARNING

OVERVIEW MANUAL MUST BE READ IN ENTIRETY

This VPI Overview manual (P2086G) should be read in its entirety prior to any operational and/or maintenance actions as it contains important safety messages and pertinent VPI information.

Failure to comply may result in an unsafe condition or accident causing property damage, injury, and/or death.

WARNING

NOTIFICATION OF SERVICE DISRUPTION

Disruption of VPI operation poses a potential threat to rail safety. Before shutting down an interlocking for any reason, the railroad dispatcher in charge of the affected route(s) must be notified. Take all steps necessary to ensure the safe passage of traffic is maintained.

Failure to comply can degrade the safety performance of the train control system resulting in property damage, injury, and/or death due to train collision or derailment.

WARNING

USE ONLY ALSTOM VITAL RELAY WITH VRD BOARD

Only Alstom VRD relay (P/N 56001-787-05) is to be used with the Alstom VPI system VRD circuit board. Alstom products are designed to function within all-Alstom systems. The introduction of non-Alstom products into an Alstom VPI system could have unintended and unforeseeable safety consequences.

Failure to comply can degrade the safety performance of the train control system resulting in property damage, injury, and/or death due to train collision or derailment.

WARNING

USE OF LRUS NOT MANUFACTURED BY ALSTOM

Alstom strongly recommends only using Lowest Replaceable Units (LRUs) manufactured by Alstom in order to maintain the safe operation of the train control system. Use of LRUs not manufactured by Alstom in the Alstom train control system can degrade the safety performance of the system resulting in property damage, injury, and/or death due to train collision or derailment.

Alstom strongly recommends that a detailed AREMA-compliant safety analysis be performed before using any LRU that is not an Alstom manufactured direct replacement for this Alstom train control system. This safety analysis should be performed by personnel with mastery in the system safety implications of using LRUs not manufactured by Alstom.

Responsibility for the adequacy of the safety analysis rests solely with the transit or railroad authority and Alstom will neither review nor approve any such safety analysis.

For train control systems designed by Alstom, the transit or railroad authority shall be solely responsible for any consequences to the safety integrity and performance of the train control system in which LRUs not manufactured by Alstom are used in the train control system originally designed, safety certified, and commissioned by Alstom. Alstom assumes no responsibility or liability for the safe performance of the train control system once LRUs not manufactured by Alstom are used.

For train control systems not designed by Alstom, the transit or railroad authority shall be solely responsible for any consequences to the safety integrity and performance of the train control system in which LRUs not manufactured by Alstom are used. Alstom assumes no responsibility or liability for the safe performance of the train control system once LRUs not manufactured by Alstom are used.

WARNING

USE OF LRUS NOT REPAIRED BY ALSTOM

Alstom strongly recommends all LRU repairs be performed by Alstom as Alstom uses special components and has developed special assembly and repair techniques to ensure the continued safety of the train control system. Use of LRUs not repaired by Alstom in the Alstom train control system can degrade the safety performance of the system resulting in property damage, injury, and/or death due to train collision or derailment.

Alstom strongly recommends that a detailed AREMA-compliant safety analysis be performed before using any LRU not repaired by Alstom in this Alstom train control system. This safety analysis should be performed by personnel with mastery in the system safety implications when using Alstom LRUs not repaired by Alstom.

Responsibility for the adequacy of the safety analysis rests solely with the transit or railroad authority and Alstom will neither review nor approve any such safety analysis.

For train control systems designed by Alstom, the transit or railroad authority shall be solely responsible for any consequences to the safety integrity and performance of the train control system in which LRUs not repaired by Alstom are used in the train control system originally designed, safety certified, and commissioned by Alstom. Alstom assumes no responsibility or liability for the safe performance of the train control system once LRUs not repaired by Alstom are used.

For train control systems not designed by Alstom, the transit or railroad authority shall be solely responsible for any consequences to the safety integrity and performance of the train control system in which LRUs not repaired by Alstom are used. Alstom assumes no responsibility or liability for the safe performance of the train control system once LRUs not repaired by Alstom are used.

WARNING

PROTECT VITAL OUTPUT EQUATIONS WITH VRDFRNT-DI

Relying on the status of the VRDFRNT-DI Vital input to, in effect, control Vital output devices without including the VRDFRNT-DI Vital input in the respective output equations does not provide fail-safe operation. The VRDFRNT-DI Vital input must be used as a constituent to the Vital output Boolean equations.

Failure to comply can degrade the safety performance of the train control system resulting in property damage, injury, and/or death due to train collision or derailment. Customer Application of VRDFRNT-DI in a non-vital manner is done so at the risk managed by the customer (Alstom Signaling takes no responsibility for that risk).

WARNING

LOAD DEVICE RESTRICTIONS FOR CODE RATE GENERATOR (CRG) BOARDS

Low current Vital CRG boards may fail with up to 3 milliamperes of output leakage current with the system requesting the output to be in the de-energized state. To prevent a potential unsafe condition, any load device attached to a low current Vital output circuit board must not operate at or below 3 milliamperes and must de-activate above 3 milliamperes. This includes all environmental operating conditions and all operating values of the load device over its service life.

Failure to follow this requirement may lead to unexpected operation of the load device resulting in property damage, injury, and/or death due to train collision or derailment.

WARNING

LOAD DEVICE RESTRICTIONS FOR SINGLE BREAK OUTPUT (SBO) BOARDS

Low current Vital SBO boards may fail with up to 3 milliamperes of output leakage current with the system requesting the output to be in the de-energized state. To prevent a potential unsafe condition, any load device attached to a low current Vital output circuit board must not operate at or below 3 milliamperes and must de-activate above 3 milliamperes. This includes all environmental operating conditions and all operating values of the load device over its service life.

Failure to follow this requirement may lead to unexpected operation of the load device resulting in property damage, injury, and/or death due to train collision or derailment.

WARNING

LOAD DEVICE RESTRICTIONS FOR DOUBLE BREAK OUTPUT (DBO) BOARDS

Low current Vital DBO boards may fail with up to 3 milliamperes of output leakage current with the system requesting the output to be in the de-energized state. To prevent a potential unsafe condition, any load device attached to a low current Vital output circuit board must not operate at or below 3 milliamperes and must de-activate above 3 milliamperes. This includes all environmental operating conditions and all operating values of the load device over its service life.

Failure to follow this requirement may lead to unexpected operation of the load device resulting in property damage, injury, and/or death due to train collision or derailment.

WARNING

LOAD DEVICE RESTRICTIONS FOR LIGHT DRIVER OUTPUT (LDO) BOARDS

High current Vital LDO boards may fail with up to 50 milliamperes of output leakage current with the system requesting the output to be in the de-energized state. To prevent a potential unsafe condition, any load device attached to a high current Vital output circuit board must not operate at or below 50 milliamperes and must de-activate above 50 milliamperes. This includes all environmental operating conditions and all operating values of the load device over its service life.

Failure to follow this requirement may lead to unexpected operation of the load device resulting in property damage, injury, and/or death due to train collision or derailment.

WARNING

LOAD DEVICE RESTRICTIONS FOR LIGHT DRIVER OUTPUT 2 (LDO2) BOARDS

High current Vital LDO2 boards may fail with up to 50 milliamperes of output leakage current with the system requesting the output to be in the de-energized state. To prevent a potential unsafe condition, any load device attached to a high current Vital output circuit board must not operate at or below 50 milliamperes and must de-activate above 50 milliamperes. This includes all environmental operating conditions and all operating values of the load device over its service life.

Failure to follow this requirement may lead to unexpected operation of the load device resulting in property damage, injury, and/or death due to train collision or derailment.

WARNING

LOAD DEVICE RESTRICTIONS FOR LOW CURRENT VITAL AC OUTPUT (ACO) BOARDS

Low current Vital AC output boards may fail with up to 3 milliamperes of output leakage current with the system requesting the output to be in the de-energized state. To prevent a potential unsafe condition, any load device attached to a low current Vital output circuit board must not operate at or below 3 milliamperes and must de-activate above 3 milliamperes. This includes all environmental operating conditions and all operating values of the load device over its service life.

Failure to follow this requirement may lead to unexpected operation of the load device resulting in property damage, injury, and/or death due to train collision or derailment.

WARNING

LOAD DEVICE RESTRICTIONS FOR HIGH CURRENT VITAL AC OUTPUT (ACO) BOARDS

High current Vital AC output boards may fail with up to 50 milliamperes of output leakage current with the system requesting the output to be in the de-energized state. To prevent a potential unsafe condition, any load device attached to a high current Vital output circuit board must not operate at or below 50 milliamperes and must de-activate above 50 milliamperes. This includes all environmental operating conditions and all operating values of the load device over its service life.

Failure to follow this requirement may lead to unexpected operation of the load device resulting in property damage, injury, and/or death due to train collision or derailment.

WARNING

INTENDED SAFE FUNCTIONALITY OF THE VPI SYSTEM MUST BE VERIFIED

The safety of the application logic as written is the responsibility of an experienced signal engineer—CAAPE does not make any determination regarding the inherent safety of the logic equations that were entered.

Verifying the accuracy with which CAAPE converted the signaling engineer's application data into PROM data structures is aided by CAAPE, but the signaling engineer must make a final determination using information supplied by CAAPE. CAAPE's compilers are not themselves Vital programs. An additional independent process is needed to verify that the compile was done correctly. This process is required for all Vital applications.

An experienced signal engineer must verify the safety of the VPI data and its application. It is the signaling engineer's responsibility to verify the correctness of the VPI input data in that it accurately represents the intended safe functionality of the VPI system. Furthermore, "verify the correctness" means that the signaling engineer (1) is required to compare the input and output data files to verify the CAA has operated correctly and (2) must test the VPI application in its intended environment before it can be placed in revenue service.

Failure to comply can degrade the safety performance of the train control system resulting in property damage, injury, and/or death due to train collision or derailment.

WARNING

VPI APPLICATION MUST BE VALIDATION TESTED

Prior to revenue service, validation testing must confirm all VPI application logic is correct and consistent with application requirements.

Failure to comply can degrade the safety performance of the train control system resulting in property damage, injury, and/or death due to train collision or derailment.

WARNING

ADV INPUT DATA MUST BE VERIFIED SEPARATELY—PRIOR TO ADV PROCESS

Vital system operation requires that the Boolean equations in the Vital application logic must be written correctly, so that by executing the logic, the VPI system operates safely in accordance with the rules of the transit or railroad authority.

The Application Data Verifier (ADV) output report provides a means to compare and verify equivalence between the input and the output application data.

However, the Application Data Verifier neither determines the safety suitability of the Boolean expression list nor determines the validity of certain encoded VPI application data. The input data to the ADV process must be verified for safety separately, prior to the ADV process, and the safety and suitability of the input data is the responsibility of the signaling engineer.

The ADV does, however, issue warnings and error messages as a result of non-vital data checking to alert the signaling engineer to possible discrepancies.

Failure to comply can degrade the safety performance of the train control system resulting in property damage, injury, and/or death due to train collision or derailment.

WARNING

VPI APPLICATION MUST BE FIELD TESTED

Field testing of a VPI application is required before placing the location into revenue service. The customer's testing plan and safety plan define the testing requirements for the VPI application.

Failure to comply can degrade the safety performance of the train control system resulting in property damage, injury, and/or death due to train collision or derailment.

WARNING

VERIFIER MUST BE DIFFERENT THAN DESIGNER

The signaling engineer responsible for verification (the Checker or Verifier) using the ADV checklist and creating the report shall be independent from the signaling engineer responsible for designing (the Designer) the VPI application.

Failure to comply can degrade the safety performance of the train control system resulting in property damage, injury, and/or death due to train collision or derailment.

WARNING

TIMER EQUATION PROTECTION REQUIRED

Vital Boolean and timer equations are evaluated in every one-second application cycle regardless of the state of the VRD, therefore every timer equation must include the VRDFRNT-DI vital input as a constituent in order to prevent the timer from running short and completing an evaluation of the equations prematurely.

Failure to comply can degrade the safety performance of the train control system resulting in property damage, injury, and/or death due to train collision or derailment.

WARNING

PROTECT VITAL OUTPUT EQUATIONS WITH VRDFRNT-DI

Relying on the status of the VRDFRNT-DI Vital input to, in effect, control Vital output devices without including the VRDFRNT-DI Vital input in the respective output equations does not provide fail-safe operation. The VRDFRNT-DI Vital input must be used as a constituent to the Vital output Boolean equations.

Failure to comply can degrade the safety performance of the train control system resulting in property damage, injury, and/or death due to train collision or derailment. Customer application of VRDFRNT-DI in a non-vital manner is done so at the risk managed by the customer (Alstom Signaling takes no responsibility for that risk).

WARNING

SOFTWARE REVISION CONTROL MUST BE MAINTAINED

Failure to properly version control VPI system software and VPI application data can result in unintended consequences including train derailment, train collision, personal injury, and/or death.

Alstom strongly recommends that strict revision control of the VPI application data and system software be maintained so that the expected configuration in the train control system is the actual installed configuration.

For train control systems designed by Alstom, the transit or railroad authority shall be solely responsible for any modifications whatsoever to the train control system which deviate from Alstom's originally delivered design, and any consequences to the system's safety integrity and performance as a result of such modifications. Alstom assumes no responsibility or liability for any modifications to the train control system or for the safe performance of the train control system once Alstom's originally delivered design has been modified.

For train control systems not designed by Alstom, the transit or railroad authority shall be solely responsible for the design of the train control system, and any consequences to the system's safety integrity and performance as a result of such designs. Alstom assumes no responsibility or liability for any designs or for the safe performance of the train control system.

WARNING

UNIQUE SITE ID CONTROL MUST BE MAINTAINED

Failure to properly assign, maintain and control unique Site IDs for VPI systems can result in unintended consequences including train derailment, train collision, personal injury, and/or death.

Alstom strongly recommends that strict control of the Site IDs be maintained so that the expected configuration of all VPIs in the train control system is the actual installed configuration.

For train control systems designed by Alstom, the transit or railroad authority shall be solely responsible for any modifications whatsoever to the train control system which deviate from Alstom's originally delivered design, and any consequences to the system's safety integrity and performance as a result of such modifications. Alstom assumes no responsibility or liability for any modifications to the train control system or for the safe performance of the train control system once Alstom's originally delivered design has been modified.

For train control systems not designed by Alstom, the transit or railroad authority shall be solely responsible for the design of the train control system, and any consequences to the system's safety integrity and performance as a result of such designs. Alstom assumes no responsibility or liability for any designs or for the safe performance of the train control system.

WARNING

ACCURATE SOFTWARE REVISION ID CONTROL MUST BE MAINTAINED

Failure to update and maintain the Software Revision IDs for **every** software change made to the VPI application data and/or system software (even a re-compile done with no software changes) jeopardizes proper software revision control and can result in unintended consequences including train derailment, train collision, personal injury, and/or death.

Alstom strongly recommends that Software Revision IDs be changed with **every** software change, even a re-compile of unchanged software. Software Revision IDs shall be maintained so that software and application revision control is maintained and the expected configuration of all VPIs in the train control system is the actual installed configuration.

For train control systems designed by Alstom, the transit or railroad authority shall be solely responsible for any modifications whatsoever to the train control system which deviate from Alstom's originally delivered design, and any consequences to the system's safety integrity and performance as a result of such modifications. Alstom assumes no responsibility or liability for any modifications to the train control system or for the safe performance of the train control system once Alstom's originally delivered design has been modified.

For train control systems not designed by Alstom, the transit or railroad authority shall be solely responsible for the design of the train control system, and any consequences to the system's safety integrity and performance as a result of such designs. Alstom assumes no responsibility or liability for any designs or for the safe performance of the train control system.

WARNING

UNIQUE SYSTEM ID CONTROL MUST BE MAINTAINED

Failure to properly assign, maintain and control a unique System ID for each VPI system within the entire train control system can result in unintended consequences including train derailment, train collision, personal injury, and/or death.

Alstom strongly recommends that strict control of the System IDs be maintained so that the expected configuration of all VPIs within the entire train control system is the actual installed configuration.

For train control systems designed by Alstom, the transit or railroad authority shall be solely responsible for any modifications whatsoever to the train control system, which deviate from Alstom's originally, delivered design, and any consequences to the system's safety integrity and performance as a result of such modifications. Alstom assumes no responsibility or liability for any modifications to the train control system or for the safe performance of the train control system once Alstom's originally delivered design has been modified.

For train control systems not designed by Alstom, the transit or railroad authority shall be solely responsible for the design of the train control system, and any consequences to the system's safety integrity and performance as a result of such designs. Alstom assumes no responsibility or liability for any designs or for the safe performance of the train control system.

WARNING

VITAL COMMUNICATIONS REQUIRE UNIQUE LINK AND BLOCK SETTINGS

Failure to properly assign, maintain and control unique Link and Block settings for Vital communications within VPI systems can result in unintended consequences including train derailment, train collision, personal injury, and/or death.

The message link and block values must be assigned such that the combination of these values is unique throughout the network.

Alstom strongly recommends that strict control of the Link and Block settings be maintained so that the expected configuration of all VPIs in the train control system is the actual installed configuration.

For train control systems designed by Alstom, the transit or railroad authority shall be solely responsible for any modifications whatsoever to the train control system which deviate from Alstom's originally delivered design, and any consequences to the system's safety integrity and performance as a result of such modifications. Alstom assumes no responsibility or liability for any modifications to the train control system or for the safe performance of the train control system once Alstom's originally delivered design has been modified.

For train control systems not designed by Alstom, the transit or railroad authority shall be solely responsible for the design of the train control system, and any consequences to the system's safety integrity and performance as a result of such designs. Alstom assumes no responsibility or liability for any designs or for the safe performance of the train control system.

WARNING

NON-VITAL SUBSYSTEM IS NOT FAIL-SAFE

The non-vital subsystem and communications software used in the VPI system is not designed for fail-safe application and must not be used for safety-critical operations.

Failure to comply can degrade the safety performance of the train control system resulting in property damage, injury, and/or death due to train collision or derailment.

SECTION 2 – INTRODUCTION

2.1 SCOPE

This document contains a general description of the Alstom VPI® Vital Processor Interlocking Control System. It contains basic, system level information, and hardware descriptions and is intended to be used to estimate the items required to satisfy a specific interlocking's control requirements.

2.2 DOCUMENT CONVENTIONS

This document provides a breakdown of the VPI product into five main subsections:

- Chassis
- Vital subsystem
- Non-vital subsystem
- Application tools
- Communication protocols.

The five main subsections are then subdivided to provide functional descriptions and electrical specifications for each base item (case, PCB, software, etc.) used to develop a complete VPI system

The VPI system does not have a fixed chassis layout. The signal engineer is allowed to configure the system within a set of constraints to best meet the needs of each particular application. The Computer Application Package (CAA) is used to configure the VPI chassis as well as define the Vital and non-vital application logic required for each system.

2.3 COMMON ABBREVIATIONS AND GLOSSARY

Terms and abbreviations used throughout this manual are provided in Table 2–1.

Table 2–1. Common Abbreviations and Glossary

Term	Definition or Explanation
AAR	Association of American Railroads, Replaced by AREMA
AC	Alternating Current
ACO	Vital AC Output board
ADV	Application Data Verifier
AF	Audio Frequency
Algorithm	A step-by-step procedure used to solve a problem
AlsDload	A tool for programming application and system software on VPI®, iVPI, PGK, PGK2, GK3, and AFTC boards
AOCD	Absence Of Current Detector
AREMA	American Railway Engineering and Maintenance of way Association
ARES	Advanced Railroad Electronic System
ATC	Automatic Train Control
ATCS	Automatic Train Control System
BBRAM	Battery-Backed Read/Write Memory
Byte	This is a group of eight bits handled as a unit
CAA	Computer-Aided Application
CAAPE	Computer-Aided Application Programming Environment
CENELEC	European Committee for Electrotechnical Standardization
CIC	Cable Integrity Check
Clock	A device in a CPU that sends out electrical pulses at a fixed rate; the control unit uses the pulses to synchronize its operation
CMOS	Complementary Metal-Oxide-Semiconductor, a major class of integrated circuits; CMOS devices use little power and do not produce as much heat as other forms of logic.
COF	Cycle of Forgiveness
CPIB	PCB Interface Chassis
Compiler	Program that translates a high-level computer language into machine language
CPU	Central Processing Unit – the computer section that handles the actual processing of data into information

Table 2–1. Common Abbreviations and Glossary (Cont.)

Term	Definition or Explanation
CPU/PD	Central Processing Unit /Polynomial Divider – board assembly containing Alstom's Vital processor and polynomial divider
CRG	Code Rate Generator board
CSEX	Extended Code System Emulator board
DBO	Double Break Output board
DC	Direct Current
De-multiplexing	The process of extracting a specific signal from a circuit carrying multiple (multiplexed) signals
DI	Direct Input board
Diagnostic	The process of detection and isolation of either a malfunction or mistake
Diagnostic Routine	A routine designed specifically to locate a malfunction in the computer
DIP	Dual In-line Package (integrated circuit)
DOT	Department Of Transportation
DPRAM	Dual-Ported Random Access Memory
Dual Port Memory	A shared memory (random access memory) that provides a mechanism for exchanging data between separate processor busses
DUART	Dual Universal Asynchronous Receiver/Transmitter
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
EPROM	A programmable read-only memory device that is erasable using high intensity ultra-violet light
Fail-Safe	The concept that if a system fails only a safe result will occur
Failure Mode	The effect by which a failure is observed, for example, short circuit
FET	Field-Effect Transistor
Firmware	Instructions stored on a ROM chip
FLASH	A form of electrically erasable programmable read only memory used with embedded processors
FMEA	Failure Mode and Effects Analysis
FPGA	Field Programmable Gate Array
FRA	Federal Railroad Administration
FSK	Frequency-shift Keying

Table 2–1. Common Abbreviations and Glossary (Cont.)

Term	Definition or Explanation
FSVT	Field Settable Vital Timer board
GVSC	A specific Vital Serial Controller board (VSC) that provides a means of communicating to and from programmable Genrakode modules.
GVSCE	A specific Vital Serial Controller board (VSC) that provides a means of communicating to and from programmable Genrakode modules.
Hardware	The electronic section of the computer that stores and manipulates symbols under the direction of the computer
HHT	Hand Held terminal
ID	Identification
I/O	Input/Output
IOB	Input/Output (I/O) Bus Interface board
Interface	The equipment that enables one kind of hardware to be recognized and processed by another kind of hardware
Interrupt	The event that tells the computer to stop the program currently running and do some other, more important task
LAN	Local Area Network
Latch	A mode of operation for a circuit in which an output's state is maintained
LDO	Lamp Drive Output board
LED	Light-Emitting Diode
Logic Symbol	A symbol used to graphically represent a logic element.
LRU	Lowest Replaceable Unit
MAC	Maintenance ACcess connection point in a system. This enables the connection of a VT100 compatible terminal to examine system diagnostics and internal operation of the system
MB	Megabyte
MMS	Maintenance Management System
MODBUS	A messaging structure used to establish master-slave/client-server communication between intelligent devices.
Modem	A piece of equipment that connects data terminal equipment to a communication line
MOV	Metal Oxide Varistor, used for voltage surge suppression
MSB	Most Significant Bit

Table 2–1. Common Abbreviations and Glossary (Cont.)

Term	Definition or Explanation
MUX	Multiplexer
MVSC	A specific Vital Serial Controller board (VSC) application that provides a means of communicating to and from AF Track Circuit modules.
NISAL	Numerically Integrated Safety Assurance Logic
Non-Vital Circuit	This circuit provides either support or secondary services for the Vital networks; its failure is not considered critical to the safe operation of a railroad but may be significant operationally
NVI	Non-Vital Input board
NVID	Non-Vital Input Differential board
NVIDSW	Non-Vital Input Differential Switch board
NVIO	Non-Vital Input/Output
NVO	Non-Vital Output board
NVOAC	Non-Vital Output AC
NVP	Non-Vital Processor board (CSEX2 or CSEX3)
NVR	Non-Vital Relay Output board
NVTWC	Non-Vital Train to Wayside Communication
PC	Personal Computer Printed Circuit
PCB	Printed Circuit Board
PD	Polynomial Divider board
Polynomial	A sum of two or more algebraic terms, each of which consists of a constant multiplied by one or more variables raised to a non-negative integral power
POR	Power On Reset
Program	A series of instructions for the computer to follow
PROM	Programmable Read-Only Memory – programmable memory devices that store firmware
RAM	Random Access Memory – this part of memory temporarily stores information that is constantly being changed in the computer; here, words may be stored (written) or read (retrieved) in any order at random
Reset	The act of changing a bit value to zero or an output to an inactive condition. Also refers to the startup or restart of a processor-based system

Table 2–1. Common Abbreviations and Glossary (Cont.)

Term	Definition or Explanation
RFI	Radio Frequency Interference
ROM	Read-Only Memory – this part of memory is built in during the integrated circuit fabrication process; ROM content cannot be altered after the chip is produced
RTC	Real-Time Clock
RTU	Relay Test Unit
SBO	Single Break Output board
Simulator	A special program that represents the behavior of a system
SMT	Surface Mount Technology
SNK	Sink
Software	Programs that direct the activity of the computer
SRAM	Static Random Access Memory
Subroutine	A section of a program that carries out a specific operation
Subsystem	Used to summarize the Vital or non-vital functions of a VPI system, as in Vital subsystem and non-vital subsystem.
Subsystem (VPI)	One of multiple subracks populated with boards in a system configuration composed of more than one subrack.
System (VPI)	One or more subracks populated with boards.
Task	A program that is run as an independent unit
TTL	Transistor-Transistor Logic
TWC	Train-to-Wayside Communications
UART	Universal Asynchronous Receiver Transmitter
USART	Universal Synchronous/Asynchronous Receiver/Transmitter
USB	Universal Serial Bus
User	An experienced signaling engineer
VA	Volt-ampere
VAC	Volts Alternating Current
Validation	CENELEC 3.1.67: the activity applied in order to demonstrate, by test and analysis, that the product meets in all respects its specified requirements.
VDC	Volts Direct Current

Table 2–1. Common Abbreviations and Glossary (Cont.)

Term	Definition or Explanation
Verification	CENELEC 3.1.68: the activity of determination, by analysis and test, at each phase of the life-cycle, that the requirements of the phase under the consideration meet the output of the previous phase and that the output of the phase under consideration fulfills its requirements.
Vital Component or Circuit	Any device, circuit or software module used to implement a Vital function; a Vital circuit is so named because its function is critical to the operation of certain signals and track equipment
Vital Function	A system, subsystem, equipment or component that provides a function critical to safety; it is implemented using fail-safe design principals, hardware, software and/or relays
VPI	Alstom's Vital Processor Interlocking product.
VRD	Vital Relay Driver board
VRMS	Volts Root Mean Square
VSC	Vital Serial Controller board that provides a means for exchanging the states of Vital interlocking functions between interlocking systems in a Vital manner.
VSL	Vital Serial Link
WAN	Wide Area Network
Watchdog Timer	A form of internal timer that is used to detect a possible malfunction; also, it is a timer set by a program to prevent the system from looping endlessly
Word	This is a group of two bytes
XOR	eXclusive OR

2.4 RELATED PUBLICATIONS

Detailed information for applying and configuring a VPI system is available in the following manuals listed in Table 2-2:

Table 2-2. Related Publications

Document No.	Title
P2086G	*VPI Product Overview*
P2086B, V1	*Installation, Operation, and Maintenance*
P2086B, V2	*Vital Printed Circuit Boards*
P2086B, V3	*Non-Vital Printed Circuit Boards*
P2086B, V4	*Module, Cables and Miscellaneous*
P2346 Series	Code/Communication System Publications (contact Alstom Signaling Inc.'s Customer Service at 1-800-717-4477 for a specific protocol)
P2509	*Maintenance Management System for Alstom Vital Processor Interlocking Systems (VPI, VPI II, iVPI)*
P2512A	*Computer-Aided Application Programming Environment (CAAPE) Software Package User Manual*
P2512B	*AlsDload Software Download User Manual*
P2512D	*VPI Computer-Aided Application (CAA) Reference Manual*
P2512E	*DataLogger*

SECTION 3 – VPI

3.1 GENERAL

This section gives general information on function and organization of the VPI system.

3.2 VPI SUBSYSTEMS

The VPI system can be subdivided into five main subsections as shown below:

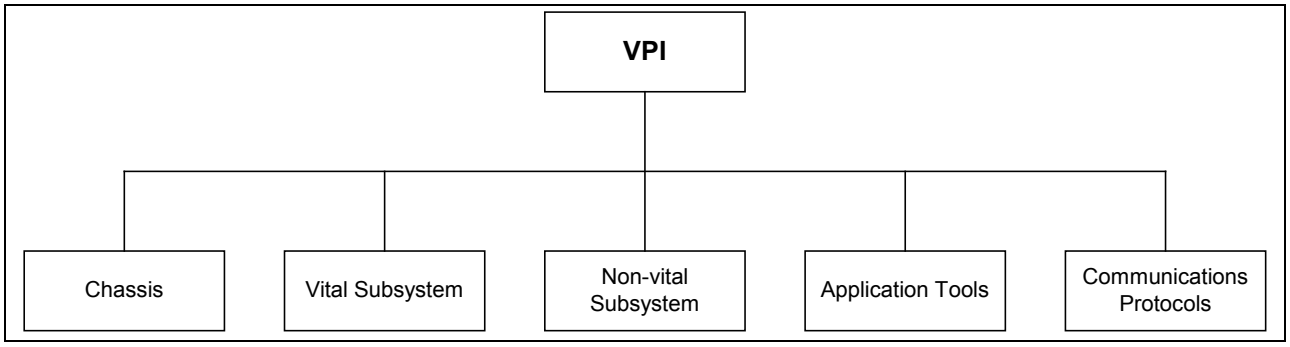

Figure 3-1. VPI Breakdown

3.3 GENERAL CHARACTERISTICS

The VPI module is a Vital fail-safe, microprocessor-based control system designed to meet the needs of interlocking control for mainline railroads and mass transit applications. Designed as a modular control system, it contains a set of plug-in Printed Circuit Boards that are applied in varying quantities to meet the needs of a specific project. Although one VPI system is sufficient for many installations, additional systems in distributed arrangements can be added for sites that are more complex (and/or have specific availability requirements). A single VPI system may include 1 to 4 chassis depending on I/O and arrangement. Single VPI systems controlling interlockings with 35 point machines have been proposed. However, the largest single VPI system installed so far has 20 points machines, and the average number of point machines per system tends to be less due to specific project availability requirements.

The VPI system can be mounted in a small, wayside equipment shelter. No special heating or cooling equipment is required for operation in AREMA-specified environments of Class C or Class D (-40 to +70 degrees C). Built-in secondary transient protection is provided for all I/O lines to prevent disruption of service from EMI or other local interference. If required, additional primary protection devices can be added to the external lines to protect against higher level EMI such as pulses from nearby electrical storms. Typically, no interface devices are required between the VPI inputs and outputs and the standard interlocking appliances.

The interlocking relay logic is reduced to either a closed set of Boolean mathematical expressions or expressed graphically using Relay/Ladder Logic diagrams which represent standard relay contact closures energizing coils. Then, using an ALSTOM Computer-Aided Application Programming Environment (CAAPE) software package, these Boolean expressions are converted into operating instructions for the VPI microprocessor. Both Vital and non-vital applications are created with the same user interface. The CAAPE software package is also used to configure the hardware of the VPI chassis.

The tool set includes a graphical simulator that allows the signal engineer to exercise the logic before building the hardware. The simulator provides a mechanism for the signal engineer to demonstrate the operation of the interlocking before the design is complete. As such, it can offer clarifying detail to design reviews. The simulator can also be used in presenting the application design to non-signaling personnel, e.g., operating personnel, to insure that the signal design adequately supports the operational needs.

The VPI system has separate subsystems for Vital and non-vital control. The Vital and non-vital logic and hardware are maintained as separate subsystems to allow modifications in one section to not affect the other. These subsystems may share a chassis or may be configured in separate chassis. Refer to Figure 3-2 for a general block diagram of a portion of a control system with two VPI systems.

3.4 GENERAL SPECIFICATIONS

Table 3–1 lists nominal specifications for the VPI module (Chassis and Boards).

Table 3–1. VPI Specifications

Characteristic	Specification
Logic Input Power	5 ±0.25 VDC at 8 amperes maximum per module
High Voltage Isolation Rating	Meets AREMA requirements
Operating Temperature	-40 to +160ºF (-40 to +70ºC)
Humidity	0 to 95% Non-Condensing
Typical Weight per Module with some boards	15 lbs. (6.80 kg)
Dimensions	14H × 19W × 23D[1] inches (35.6H × 48.3W × 58.5D cm)

[1] Depth includes cable dress at rear of chassis

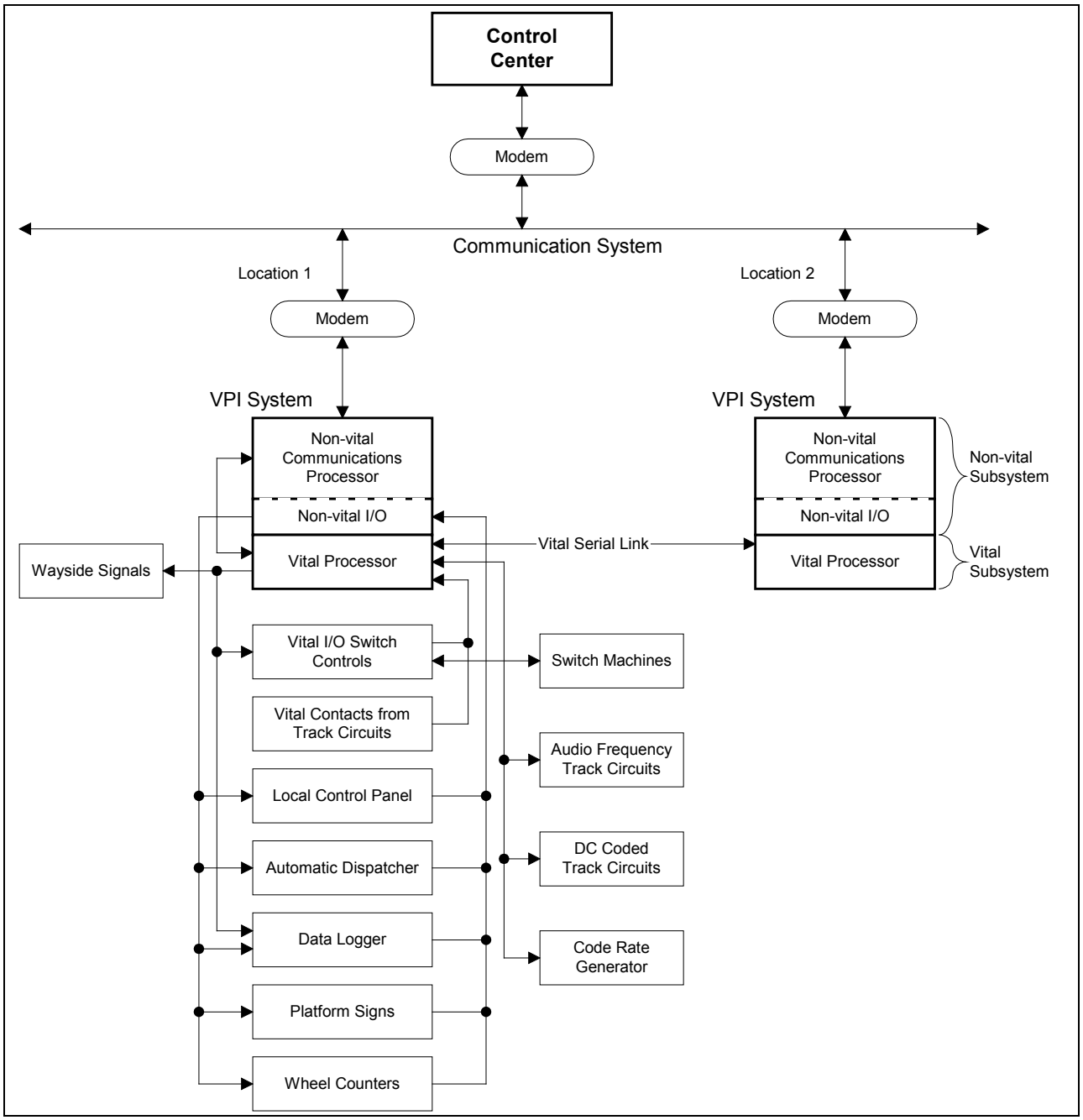

Figure 3-2. General VPI System Block Diagram

SECTION 4 – CHASSIS CONFIGURATIONS

4.1 GENERAL

This section describes the chassis used for the VPI system.

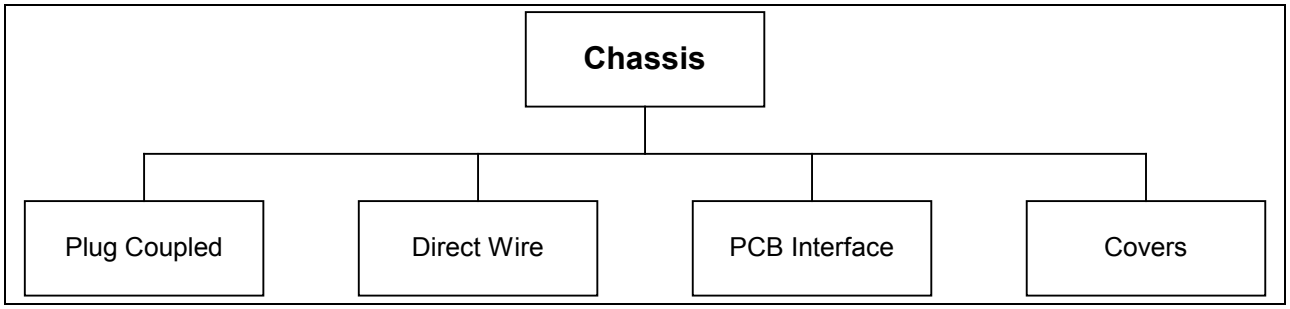

Figure 4-1. VPI Chassis

4.2 PLUG COUPLED CHASSIS

The VPI plug coupled chassis includes internal cable harness assemblies. These assemblies connect the VPI PCB I/O point(s) to a series of AMP type M-series plug couplers, mounted on the rear panel of the chassis. The rear panel also contains a 14-pin type M-series plug coupler for the 5 VDC power connection and provisions for up to four 60-way ribbon cable connectors for connecting to expansion chassis.

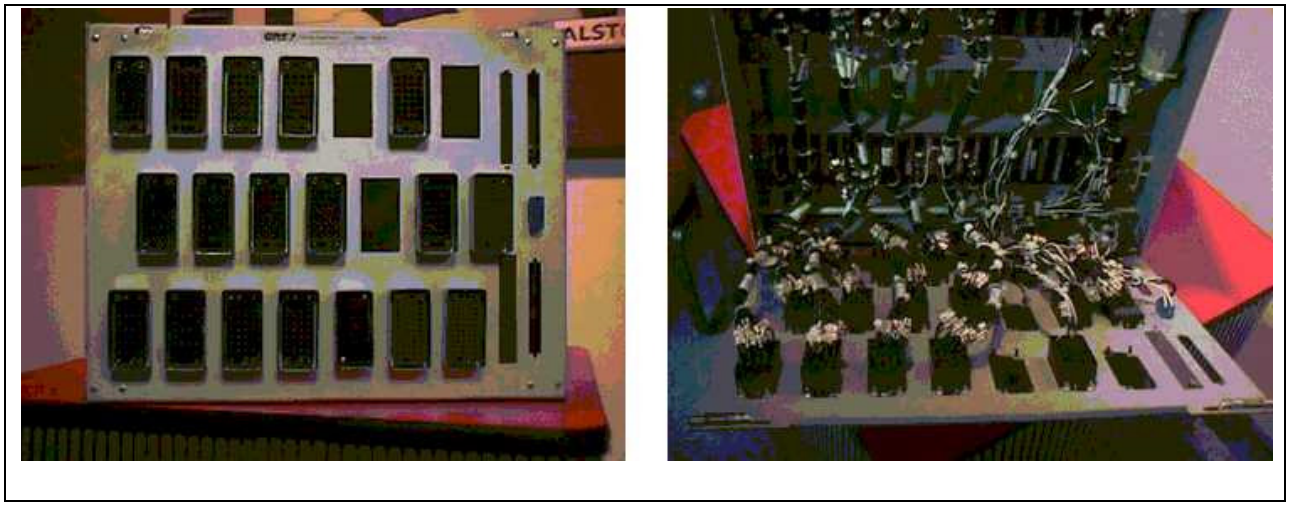

Figure 4-2. Plug Coupled Chassis

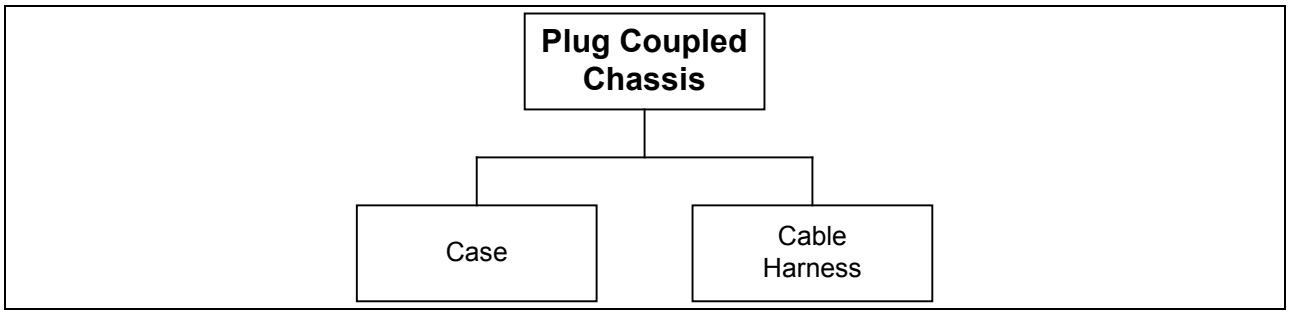

Figure 4-3. Plug Coupled

4.2.1 Case

The VPI plug coupled chassis can be provided in two basic case configurations. One to four chassis can be used to complete a single system. The chassis may be a mixture of the two types. The two basic types are the split motherboard and the continuous motherboard that busses the center connector (P2) of the printed circuit boards together. Each chassis contains 21 printed circuit board slots.

The split motherboard version of the chassis is configured to connect the P2 connector traces from chassis slots one through five together and slots six through twenty-one together. Since the VPI system uses the P2 connector as the I/O bus this allows Vital and non-vital I/O to be housed in the same chassis. For example, the first five chassis slots could be used to house non-vital I/O and the non-vital processor. Slots from 6 to 21 could contain Vital I/O along with the Vital I/O controller (I/O Bus).

Note: Other system boards may also be required to configure a proper operating system and several other arrangements could be possible.

The continuous motherboard version of the plug-coupled module connects all the slots (1–21) of the P2 connector together. This requires that all the I/O housed in the module be either Vital or non-vital. Also a CSEX board can be housed in this module with Vital I/O as long as no non-vital I/O are also housed.

Table 4–1. VPI Plug Coupled Chassis Configurations

Description	Part Number
Plug coupled chassis with split motherboard (5/16 slots), 5 VDC power filter and 38216-404 Bus Extension Cable	31506-015-01
Plug coupled chassis with continuous motherboard (21 slots), 5 VDC power filter and 38216-404 Bus Extension Cable	31506-015-11
Extra deep plug coupled chassis with rear cover, split motherboard, and 5 VDC power filter	31506-015-15
Extra deep plug coupled chassis with rear cover, continuous motherboard, 5 VDC power filter and	31506-015-16

4.2.2 Cable Harness

The chassis requires specific cable harness assemblies to be installed based on the PCB configuration. Ribbon cables are required for the main system bus. This is a 60-way ribbon cable, which connects the main system boards together. The number of positions or slots required for this cable is dependent upon the number of main boards being installed. The boards connected by this main bus are CSEX, VRD, CPU/PD, I/O BUS, and VSC. The VRD PCB takes two slots.

Cable harnesses are also required to connect the PCB edge connectors to the plug couplers on the rear cover of the chassis. These cables are detailed below. There are 21 available plug coupler locations on the rear panel and four 60 way ribbon cable locations. The blank plates listed below are used to cover the unused locations. Also note that there are several variations of output and input cables to provide a variety of arrangements of plug couplers and board configurations.

4.3 DIRECT WIRE CHASSIS

The direct wire chassis is configured to allow the I/O wiring to be economical by directly inserting wire into the PCB edge connectors in the chassis. This chassis configuration does not allow for quick removal of the chassis from a wired rack. However, all the PCBs can be removed and no active electronic components are left in the chassis. This version is intended for applications where the rack housing this chassis provides a plug-coupled connection to the other interlocking equipment.

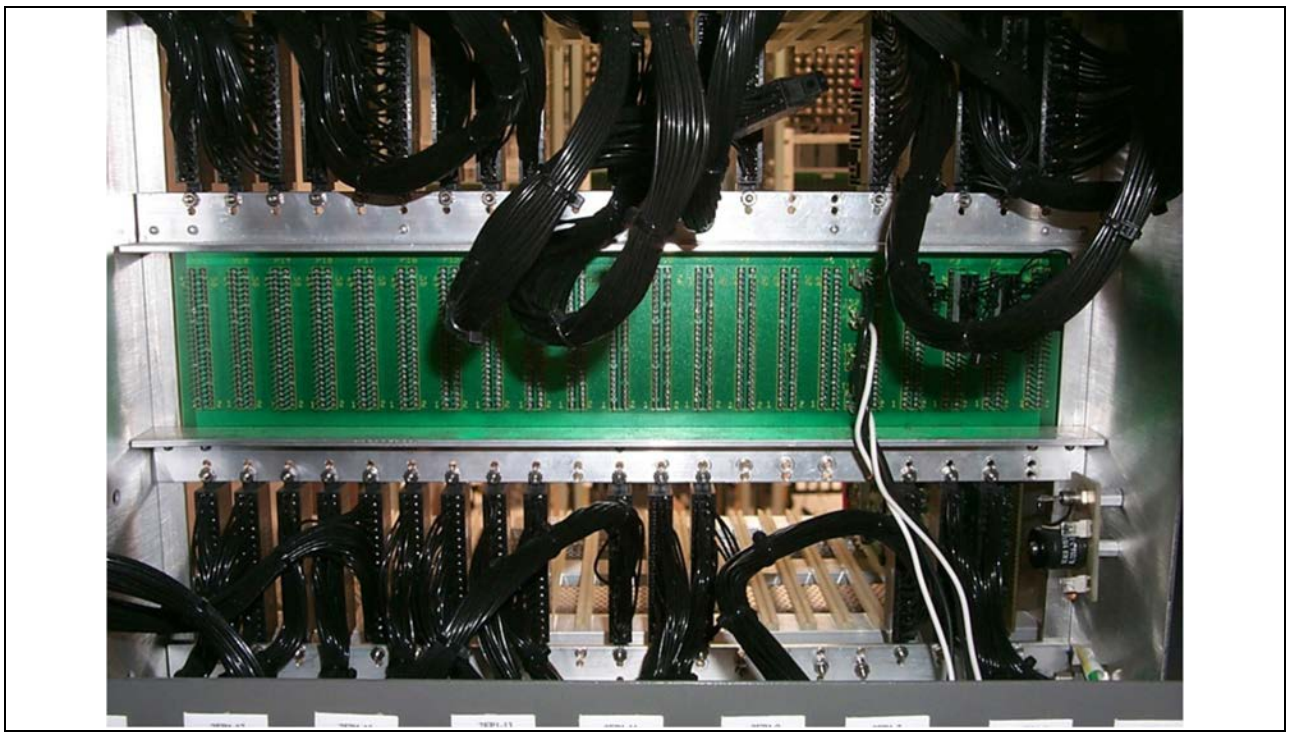

Figure 4-4. Direct Wire Chassis

4.3.1 Case

The VPI direct wired chassis can be constructed from two basic case configurations. One to four chassis can be used to complete a system. The chassis may be a mixture of the two types. The two basic types are the split motherboard and the continuous motherboard that busses the center connector (P2) of the printed circuit boards together. All chassis contain 21 printed circuit board slots.

The split motherboard version of the chassis is configured to connect the P2 connector traces from chassis slots one through five together and slots six through 21 together. Since the VPI system uses the P2 connector as the I/O bus this allows Vital and non-vital I/O to be housed in the same chassis. For example, the first five chassis slots could be used to house non-vital I/O and the non-vital processor. Slots from 6 to 21 could contain Vital I/O along with the Vital I/O controller (I/O Bus).

Note: Other system boards may also be required to configure a proper operating system and several other arrangements could be possible.

The continuous motherboard version of the plug-coupled module connects all the slots (1 –21) of the P2 connector together. This requires that all the I/O housed in the module be either Vital or non-vital. Also, a CSEX board can be housed in a module with Vital I/O as long as no non-vital I/O are also housed.

This chassis can also be supplied with an optional rear panel. This panel is used to provide connection points for diagnostic equipment connections; chassis to chassis ribbon cable connections and power supply connections.

An extra deep, plug coupled chassis is offered to provide more space for internal cables such as the 38216-497-xx cable assemblies. For those systems with large numbers of I/O’s this makes access to the back of the motherboard and 5 VDC power filter easier.

Table 4–2. VPI Direct Wire Chassis Configurations

Description	Part Number
Direct wired chassis with rear panel, split motherboard, and 5 VDC power filter. Note: use with 38216-404-KN bus ext. cables.	31506-015-02
Chassis with split motherboard, 5 VDC power filter, NO rear panel or rear cover.	31506-015-03
Direct wired chassis with rear panel, continuous motherboard, and 5 VDC power filter	31506-015-12
Chassis with continuous motherboard, 5 VDC power filter, NO rear panel or rear cover.	31506-015-13
Direct wired chassis with rear panel, split motherboard, and 5 VDC power filter Note: use with 38216-504-KN bus ext. cables.	31506-015-14
Direct wired chassis with split motherboard, rear cover	31506-015-17
Direct wired, deep chassis with continuous motherboard, rear cover	31506-015-18

4.3.2 Cables

The chassis required specific cables to be installed based on the PCB configuration. Cables are required for the main system bus. This is a 60-way ribbon cable, which connects the main system boards together. The number of positions or slots required for this cable is dependent upon the number of main boards being installed. The boards connected by this main bus are CSEX, VRD, CPU/PD, I/O BUS, and VSC. The VRD PCB takes two slots.

4.4 PCB INTERFACE CHASSIS (CPIB)

The PCB interface chassis uses printed circuit cards with WAGO style (spring clip) wire termination blocks and PCB edge connectors to map the I/O termination points on the VPI PCBs to discrete wire connectors. The chassis is designed to allow these interface PCBs to be inserted and removed from the rear of the chassis. This provides a wire termination method that can be quickly disconnected (by removing the PCBs) and individual I/O points may be disconnected for troubleshooting. This chassis style is intended for low density applications. See Figure 4-5 for a photo of a PCB Interface Chassis.

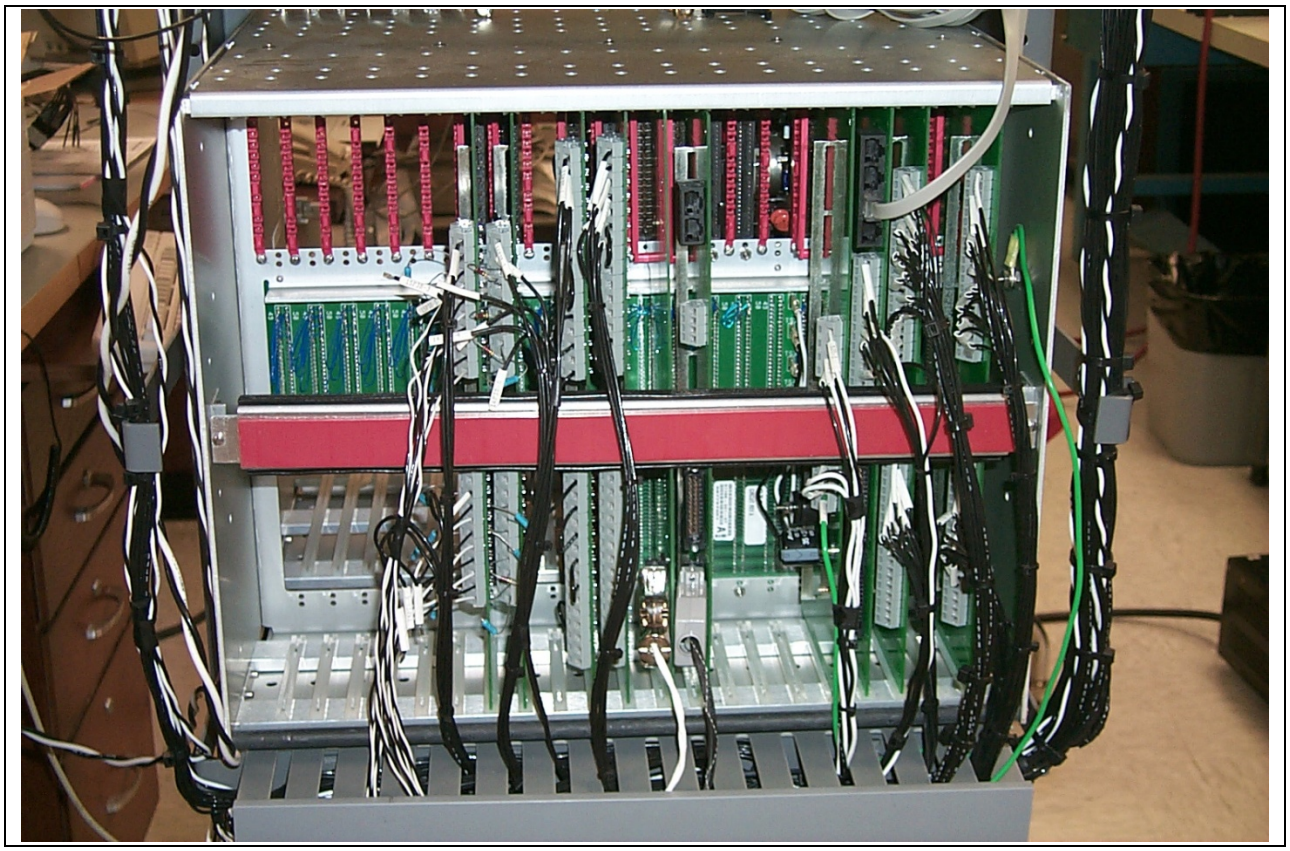

Figure 4-5. PCB Interface Chassis

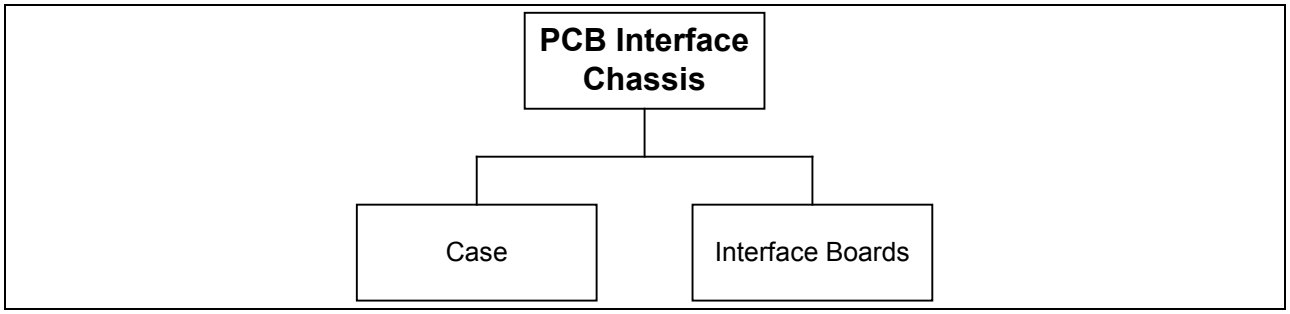

Figure 4-6. PCB Interface

4.4.1 Case

The PCB Interface case is similar in arrangement and options to the plug-coupled and direct wired cases. The difference in this case is that an additional set of card guides are installed on the rear of the chassis for the interface PCBs. The case descriptions in Table 4–3 include a list of the boards in each case. The individual boards are discussed in SECTION 5 – Vital Subsystem and SECTION 6 – Non-Vital Subsystem..

This chassis uses a fixed PCB for the main system bus and therefore a main system cable is not used.

Table 4–3. VPI PCB Interface Chassis Configurations

Description	Part Number
Case with split MB, VRD, IOB, CPU/PD, DI and DBO	31038-274-01
Case with split MB, CSEX3, VRD, IOB, CPU/PD, VSC, DI, DBO and LDO	31038-274-02
Case with split MB, CSEX3, VRD, IOB, CPU/PD, VSC, FSVT, DI, DBO and LDO	31038-274-03
Case with split MB, CSEX3, VRD, IOB, CPU/PD, VSC, DI, DBO and LDO	31038-274-04
Case with split MB, CSEX3, VRD, IOB, CPU/PD, VSC, DI and DBO	31038-274-05

4.4.2 Cables

The following 60-conductor ribbon cables support connection of CPU/PD header and rear panel bulkhead mount to support connection to CPU/PD assembly via the 38216-589-00 cable.

The following 10-conductor ribbon cables support the connection of CRG Boards to the CPU/PD Boards.

Table 4–4. Ribbon Cable Part Numbers

Board Connect Between		Description	Part Number
CPU/PD Board Header	Rear Panel VPI case	60 Conductor Ribbon Cable, 18 inches	38216-625-01
CPU/PD Board Header	Rear Panel VPI case	60 Conductor Ribbon Cable, 27 inches	38216-625-02
CRG Board 31166-544-01 (P1 Interconnect)	CRG Board 31166-544-01 (P1 Interconnect)	10 Conductor Ribbon Cable, 6 inches	38216-629-00
CPU/PD Board 31166-543-01 (P3 Interconnect)	CRG Board 31166-544-01 (P1 Interconnect)	10 Conductor Ribbon Cable, 18 inches	38216-630-00

4.4.3 Interface PCBs

Table 4–5. Interface Assembly Differences

Description	Part Number
Vital output PCB interface	31166-194-01
Vital input interface	31166-195-01
Non-vital interface	31166-196-01
VRD and 5 VDC Power interface	31166-197-01
VSC interface	31166-198-01
Communications interface (CSEX)	31166-199-01
CPU/PD interface	31166-336-01

4.5 COVERS

The VPI chassis can be supplied with optional covers. The front cover is a hinged aluminum cover on which the PCB label is generally mounted. The chassis can also be supplied with either a top or bottom screen or both. This screen is generally used to prevent items from falling into the PCB area of the equipment.

Table 4–6. VPI Chassis Covers

Description	Part Number
Front cover	58605-043-02
Top/bottom screen cover	50253-354-00

SECTION 5 – VITAL SUBSYSTEM

5.1 GENERAL

This section describes the Vital boards and assemblies used in the VPI system.

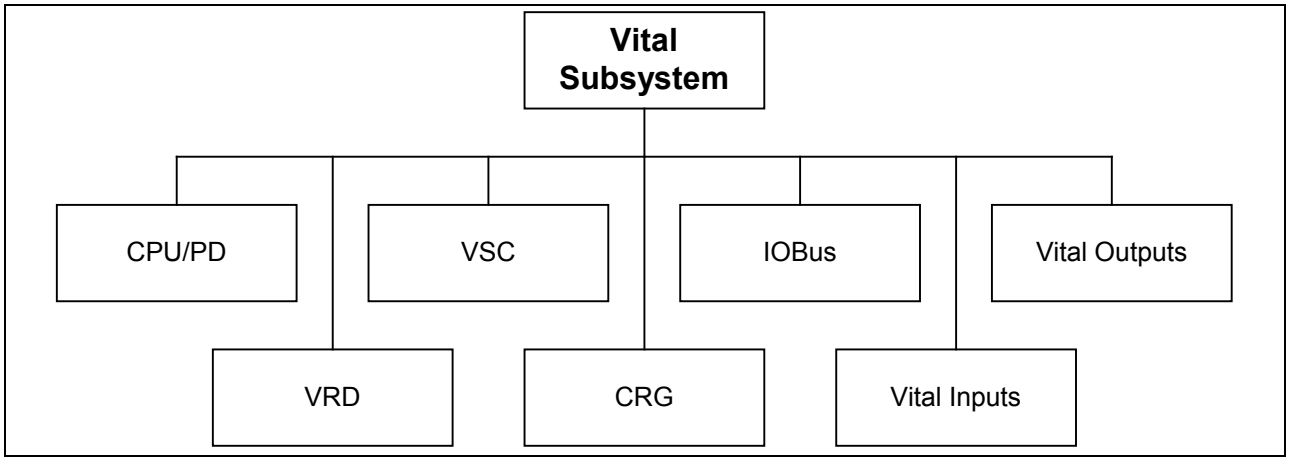

Figure 5-1. Vital Subsystem

5.2 CPU/PD (CENTRAL PROCESSING UNIT/POLYNOMIAL DIVIDER) BOARD P/N 31166-029

All the Vital application logic is stored on this board and executed from it. Each Vital subsystem requires one of these boards.

All the Vital control and monitoring functions for the VPI module go through this board. The CPU/PD board controls the System bus over which the CPU/PD, VRD, CSEX, VSC and I/O Bus interface boards communicate.

5.2.1 High Integration Embedded Microprocessor

The 16 MHz microprocessor (180C186EB-16) on this board has many integrated features. All of these features are used on the CPU/PD board to provide a compact, high-speed board set. The increased speed and memory capacity of the board afford increased Vital I/O and Vital expression capacities.

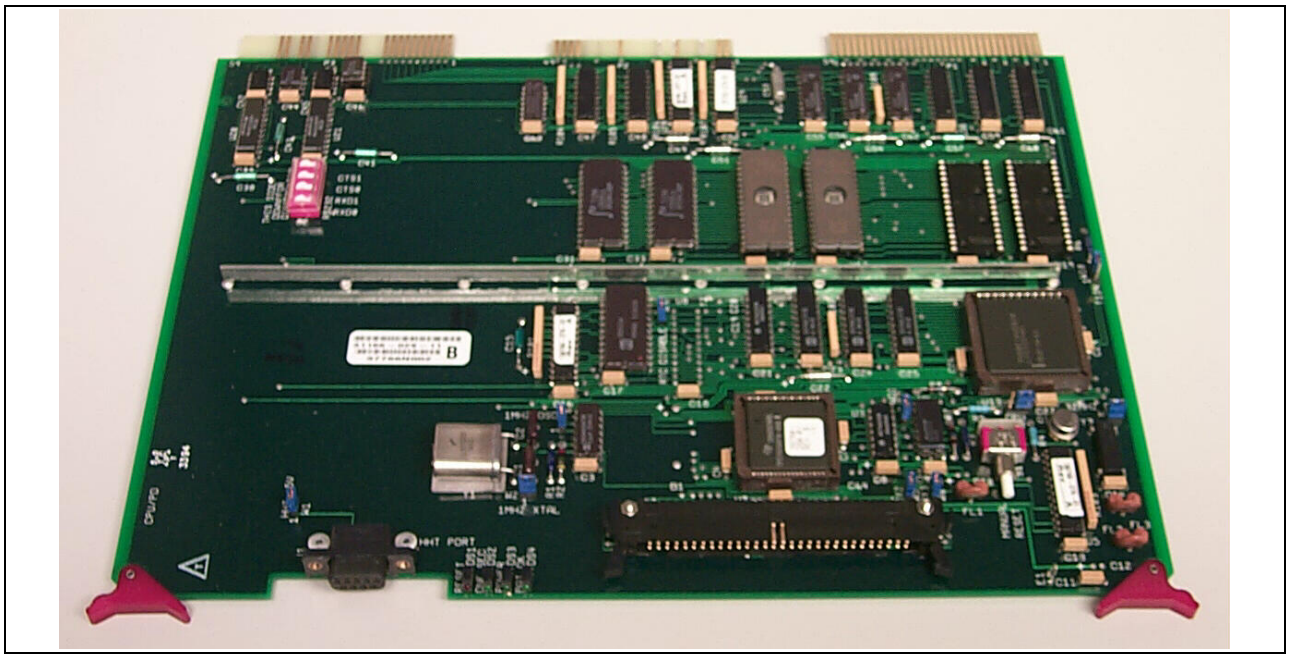

Figure 5-2. CPU/PD Board

5.2.2 Specifications

Table 5–1. CPU/PD Board Specifications

Characteristic	Specification
Maximum number of Boards per VPI System	1
Board slots required	1
Maximum Board Logic Current Supply	500 mA
Maximum Board Logic Current Supply with HHT	600 mA
Supports 27H010 EPROM	Yes

5.2.3 Assemblies

Table 5–2. CPU/PD Board Assembly

Description	Part Number
Basic Board, No VPI System Software	31166-029-01
Board with 40026-081 Software (for use with CAA 31746-010 and earlier)	31166-029-10
Board with 40025-191B Software (for use with CAA 31746-011B and later)	31166-029-11
Board with 40025-304A Software (for use with CAA 31746-025A and later)	31166-029-25
Board with 40025-321A Software (for use with CAA 31746-027A and later)	31166-029-27
Board with 40025-328A Software (for use with CAA 31746-028A and later)	31166-029-28
Board with 40025-329A Software (for use with CAA 31746-029A and later)	31166-029-29
Board with 40025-347A Software (for use with CAA 31746-030D and later)	31166-029-30
Board with 40025-356A Software (for use with CAA 31746-031A and later)	31166-029-31
Board with 40025-366A Software (for use with CAA 31746-032A and later)	31166-029-32
Board with 40025-404A Software (for use with CAA 31746-033A and later)	31166-029-33

5.3 VRD (VITAL RELAY DRIVER) BOARD P/N 59473-740

This board plays a key role in assuring the vitality of the system. It produces an output voltage that operates a 100-ohm Alstom Type B1 relay (56001-787-05) if, and only if, the data sent to it by the main processing system is exactly correct. If any of these checkwords are not precisely correct, the VRD output is shut off and the external relay de-energizes. The field energy that is delivered to the Vital output boards is broken through front contacts of this Vital relay or a repeater of it. Thus, power will be removed from the outputs when the Vital checkwords are incorrect.

5.3.1 VRD Relay

WARNING

USE ONLY ALSTOM VITAL RELAY WITH VRD BOARD

Only Alstom VRD relay (P/N 56001-787-05) is to be used with the Alstom VPI system VRD circuit board. Alstom products are designed to function within all-Alstom systems. The introduction of non-Alstom products into an Alstom VPI system could have unintended and unforeseeable safety consequences.

Failure to comply can degrade the safety performance of the train control system resulting in property damage, injury, and/or death due to train collision or derailment.

WARNING

USE OF LRUS NOT MANUFACTURED BY ALSTOM

Alstom strongly recommends only using Lowest Replaceable Units (LRUs) manufactured by Alstom in order to maintain the safe operation of the train control system. Use of LRUs not manufactured by Alstom in the Alstom train control system can degrade the safety performance of the system resulting in property damage, injury, and/or death due to train collision or derailment.

Alstom strongly recommends that a detailed AREMA-compliant safety analysis be performed before using any LRU that is not an Alstom manufactured direct replacement for this Alstom train control system. This safety analysis should be performed by personnel with mastery in the system safety implications of using LRUs not manufactured by Alstom.

Responsibility for the adequacy of the safety analysis rests solely with the transit or railroad authority and Alstom will neither review nor approve any such safety analysis.

For train control systems designed by Alstom, the transit or railroad authority shall be solely responsible for any consequences to the safety integrity and performance of the train control system in which LRUs not manufactured by Alstom are used in the train control system originally designed, safety certified, and commissioned by Alstom. Alstom assumes no responsibility or liability for the safe performance of the train control system once LRUs not manufactured by Alstom are used.

For train control systems not designed by Alstom, the transit or railroad authority shall be solely responsible for any consequences to the safety integrity and performance of the train control system in which LRUs not manufactured by Alstom are used. Alstom assumes no responsibility or liability for the safe performance of the train control system once LRUs not manufactured by Alstom are used.

WARNING

USE OF LRUS NOT REPAIRED BY ALSTOM

Alstom strongly recommends all LRU repairs be performed by Alstom as Alstom uses special components and has developed special assembly and repair techniques to ensure the continued safety of the train control system. Use of LRUs not repaired by Alstom in the Alstom train control system can degrade the safety performance of the system resulting in property damage, injury, and/or death due to train collision or derailment.

Alstom strongly recommends that a detailed AREMA-compliant safety analysis be performed before using any LRU not repaired by Alstom in this Alstom train control system. This safety analysis should be performed by personnel with mastery in the system safety implications when using Alstom LRUs not repaired by Alstom.

Responsibility for the adequacy of the safety analysis rests solely with the transit or railroad authority and Alstom will neither review nor approve any such safety analysis.

For train control systems designed by Alstom, the transit or railroad authority shall be solely responsible for any consequences to the safety integrity and performance of the train control system in which LRUs not repaired by Alstom are used in the train control system originally designed, safety certified, and commissioned by Alstom. Alstom assumes no responsibility or liability for the safe performance of the train control system once LRUs not repaired by Alstom are used.

For train control systems not designed by Alstom, the transit or railroad authority shall be solely responsible for any consequences to the safety integrity and performance of the train control system in which LRUs not repaired by Alstom are used. Alstom assumes no responsibility or liability for the safe performance of the train control system once LRUs not repaired by Alstom are used.

WARNING

PROTECT VITAL OUTPUT EQUATIONS WITH VRDFRNT-DI

Relying on the status of the VRDFRNT-DI Vital input to, in effect, control Vital output devices without including the VRDFRNT-DI Vital input in the respective output equations does not provide fail-safe operation. The VRDFRNT-DI Vital input must be used as a constituent to the Vital output Boolean equations.

Failure to comply can degrade the safety performance of the train control system resulting in property damage, injury, and/or death due to train collision or derailment. Customer Application of VRDFRNT-DI in a non-vital manner is done so at the risk managed by the customer (Alstom Signaling takes no responsibility for that risk).

Every Vital system requires at least one B relay which is operated by the VRD and through whose front contacts all the energy for the Vital outputs is broken. This relay must be, and must only be replaced by, an Alstom VRD Relay, part number 56001-787-05, 100 ohm B relay.

A front contact from the VRD Relay must be fed back into the VPI system as a Vital input for use in the application, for example, to prevent Vital timers from starting when the VRD is de-energized. The name of this Vital input may be VRDFRNT-DI.

Note: The front contact used as the Vital input is also available to supply energy to Vital outputs.

5.3.2 Physical Characteristics

The processing portion of the VRD board is based on an 8085 microprocessor chip with 4K of EPROM program memory and 4K of RAM. The RAM is shared with the main processing system and is the means by which the checkwords are transferred.

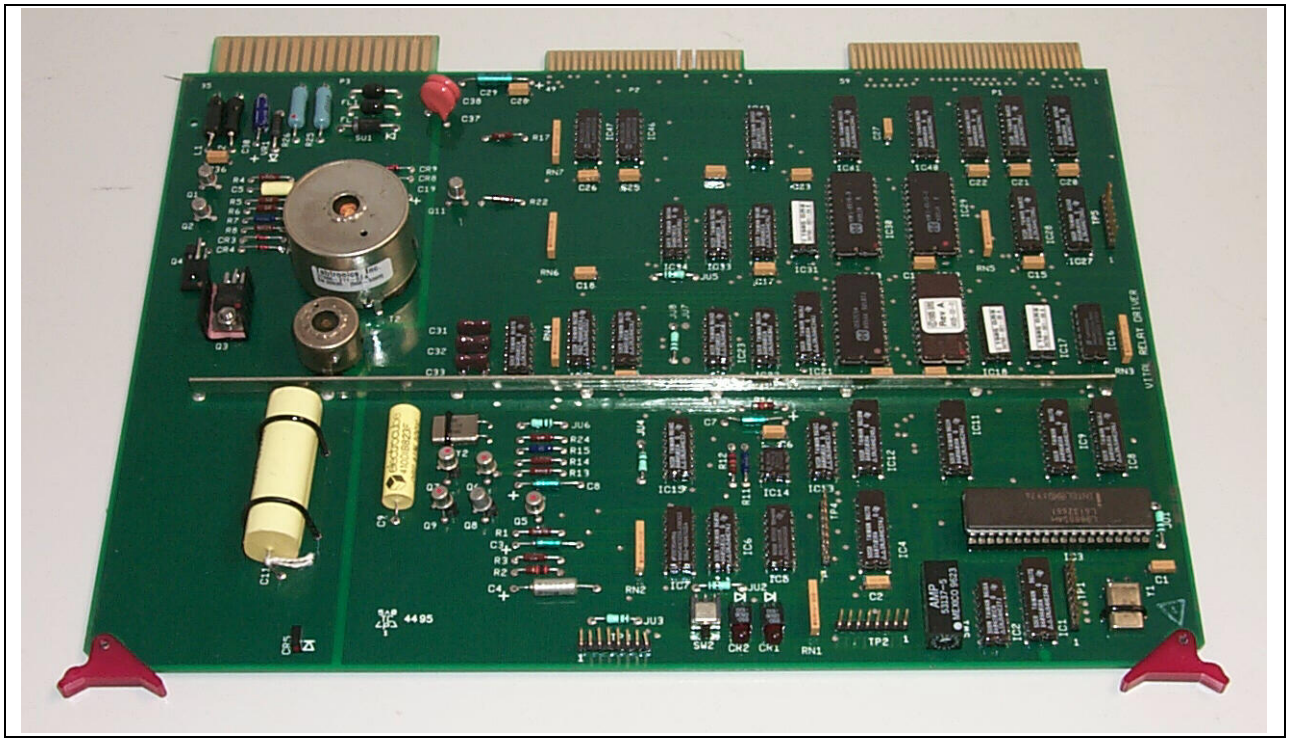

Figure 5-3. VRD Board

5.3.3 Specifications

Table 5–3. VRD Board Specifications

Characteristics	Specification
Maximum number of Boards per VPI System	1
Board slots required	2
Maximum Board Logic Current Supply	300 mA
VRD Drive Output Isolation	>3000 Vrms
Minimum VRD Supply Voltage	9.00 VDC
Maximum VRD Supply Voltage	15.00 VDC
Typical VRD Drive Current draw @ 12.00 V	40 mA

5.3.4 Assemblies

Table 5–4. VRD Board Assembly

Description	Part Number
Vital Relay Driver board assembly	59473-740-02

5.4 VSC (VITAL SERIAL CONTROLLER) BOARD P/N 59473-939

The Vital Serial Controller board is a microprocessor-based board that provides a means for exchanging the states of Vital interlocking functions between interlocking systems in a Vital manner. This board family was first designed to provide Vital VPI-to-VPI Vital communications more efficiently than line wires. There are two types of data transmission interfaces; one for private copper pairs and one for generic, EIA232, DCE connection. A daughter board is used to provide the EIA232 connection, so the number of chassis slots required for this interface is two (2).

Two additional applications of the VSC were created to provide a means of communicating to and from AF Track Circuit modules (MVSC) and programmable Genrakode modules (GVSC).

The system software installed on the Vital Serial Controller board is associated with a particular version of system software on the Vital processor board. Each type of board, MVSC, GVSC, or VSC, has its own unique Vital system software that is not interchangeable.

5.4.1 System Capacity

The VSC, used for VPI to VPI communications, sends and receives up to 200 Vital parameters of information in its message for up to ten boards depending on the system arrangement. When used for MVSC up to 450 Vital parameters can be transmitted in each direction. The GVSC sends and receives up to 30 Vital parameters of information in its messages to each of a maximum of two Genrakode modules. Up to ten VSC boards or combinations of VSC, MVSC, GVSC and CRG boards can be supported by a single Vital subsystem. See Table 5–5 for more information on permissible combinations of these boards.

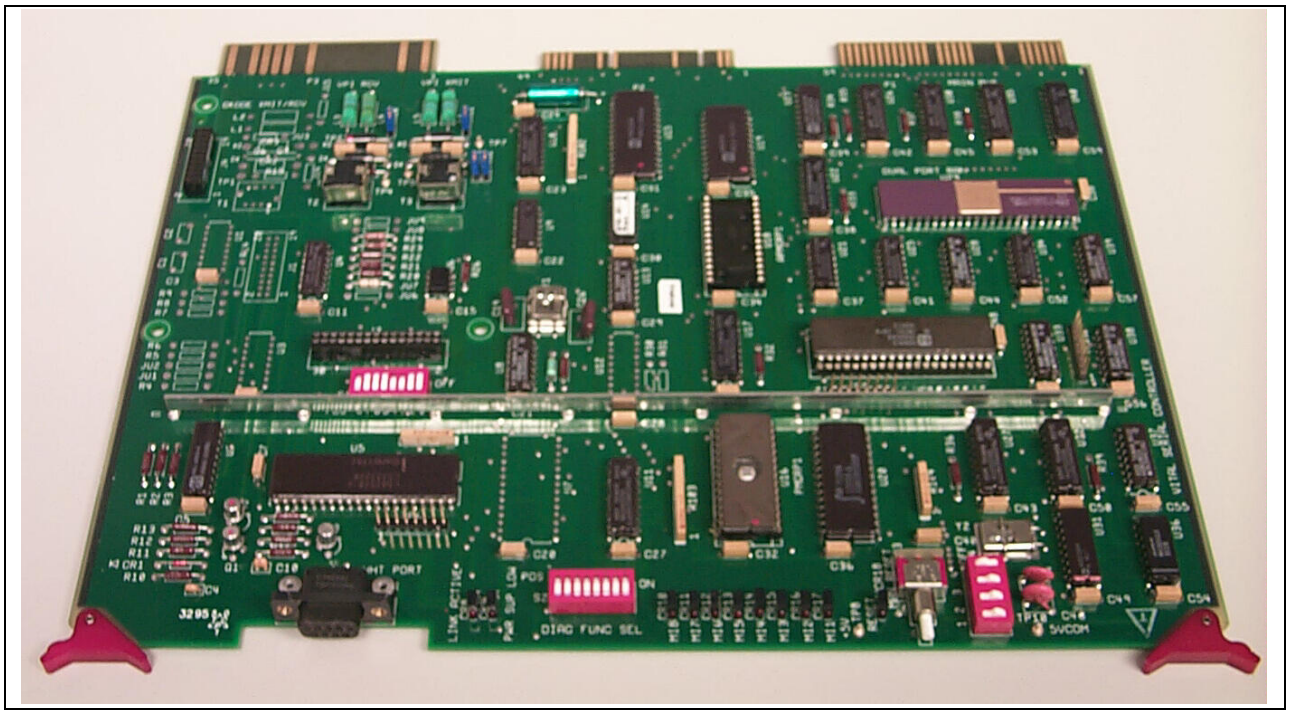

Figure 5-4. VSC Board

5.4.2 Specifications

Table 5–5. VSC Board Specifications

Ass'y No. 59473 -939-	Type	Maximum # of Boards per VPI System	Board slots req'd	Maximum Board Logic Current Supply	Baud Rate
01	Pt - Pt	4 (Note 1)	1	500 mA	19200 (Sync.)
04	Pt - Pt	4 (Note 1)	1	500 mA	19200 (Sync.)
05	Multi-drop full duplex 4-wire (Note 3)	2 (Note 2)	1	500 mA	19200 (Sync.)
06	Pt.-Pt. with daughter board	4 (Note 1)	2	500 mA	9600 or 19200 (Async. or Sync.)
07	Multi-drop, half duplex 2-wire (Note 3)	2 (Note 2)	1	500 mA	19200 (Sync.)
10	Pt - Pt	4 (Note 1)	1	500 mA	19200 (Sync.)
11	Pt.-Pt. with daughter board	4 (Note 1)	2	500 mA	9600 or 19200 (Async. or Sync.)
12	Multi-drop full duplex 4-wire (Note 3)	2 (Note 2)	1	500 mA	19200 (Sync.)
13	Multi-drop, half duplex 2-wire (Note 3)	2 (Note 2)	1	500 mA	19200 (Sync.)
14	Multi-drop, half duplex 2-wire (Note 4)	2 (Note 2)	1	500 mA	19200 (Sync.)
15	Pt - Pt	4 (Note 1)	1	500 mA	19200 (Sync.)
16	Pt.-Pt. with daughter board	4 (Note 1)	2	500 mA	9600 or 19200 (Async. or Sync.)
17	Pt - Pt	4 (Note 1)	1	500 mA	19200 (Sync.)
18	Pt.-Pt. with daughter board	4 (Note 1)	2	500 mA	9600 or 19200 (Async. or Sync.)

Note: 1. Starting with CAA 31746-025, this limit is increased to 10 minus the sum of (#VSC + #MVSC + #GVSC + #GVSCE + #CRG + #CSEX), where # indicates the total number of a particular VPI board type.

Note: 2. The total number of GVSCE + GVSC + MVSC combinations must be less than or equal to 2.

Note: 3. Supports 15 parameters per track.

Note: 4. Supports 25 parameters per track.

5.4.3 Assemblies

Table 5–6. VSC Board Assembly Differences

Description	Part Number
Pt.-Pt. with 40026-081 VSC Software (for use with CAA 31746-010 and earlier)	59473-939-01
Pt.-Pt. with 40026-192 VSC Software (for use with CAA 31746-011 and later)	59473-939-04
Multi-drop, full duplex, four-wire with 40026-193 MVSC software (for use with CAA 31746-011 and later)	59473-939-05
Pt.-Pt. with daughter board and 40026-192 VSC software (for use with CAA 31746-011 and later)	59473-939-06
Multi-drop, half duplex, two-wire with 40025-290 GVSC software (for use with CAA 31746-023 and later)	59473-939-07
Pt.-Pt. with 40025-322 VSC Software (for use with CAA 31746-027 and later)	59473-939-10
Pt.-Pt. with daughter board and 40025-322 VSC software (for use with CAA 31746-027 and later)	59473-939-11
Multi-drop, full duplex, four-wire with 40025-323 MVSC software (for use with CAA 31746-027 and later)	59473-939-12
Multi-drop, half duplex, two-wire with 40025-324 GVSC software (for use with CAA 31746-023 and later)	59473-939-13
Multi-drop, half duplex, two-wire with 40025-348 GVSCE software (for use with CAA 31746-030 and later)	59473-939-14
Pt.-Pt. with 40025-399 VSC Software (for use with CAA 31746-032H)	59473-939-15
Pt.-Pt. with daughter board and 40025-399 VSC software (for use with CAA 31746-032H)	59473-939-16
Pt.-Pt. with 40025-406 VSC Software (for use with CAA 31746-032K and later)	59473-939-17
Pt.-Pt. with daughter board and 40025-406 VSC software (for use with CAA 31746-032K and later)	59473-939-18

5.5 CRG (CODE RATE GENERATOR) BOARD P/N 31166-261

The Code Rate Generator Board is a Vital VPI board that receives code rate commands from the VPI CPU/PD board. The received code rate commands are decoded and used to generate 8 coded outputs. The frequency and duty-cycle of the coded outputs are vitally verified by using an absence of current detector (AOCD). During the on and off portions of an output's coding cycle, data is circulated through the AOCD. Data returned from the AOCD, coupled with other NISAL processing verifications, are used to generate a message that the CRG board sends to the VPI CPU/PD board. The message received by the CPU/PD board from the CRG is used as part of the generation of the VRD checkword. All outputs are generated using a Double Break Output (DBO) DC-DC converter and, as such, are isolated from each other by >2000 Vrms and protected from undetected single fault failures.

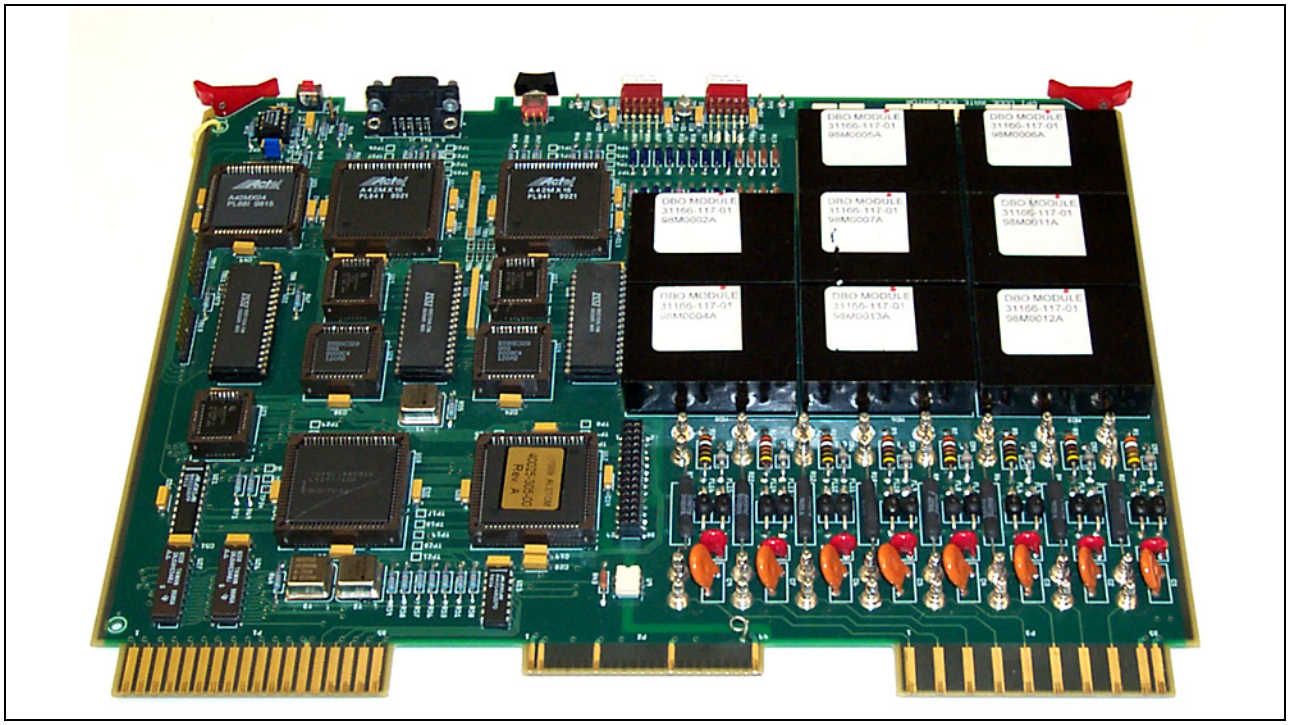

Figure 5-5. CRG Board

WARNING

LOAD DEVICE RESTRICTIONS FOR CODE RATE GENERATOR (CRG) BOARDS

Low current Vital CRG boards may fail with up to 3 milliamperes of output leakage current with the system requesting the output to be in the de-energized state. To prevent a potential unsafe condition, any load device attached to a low current Vital output circuit board must not operate at or below 3 milliamperes and must de-activate above 3 milliamperes. This includes all environmental operating conditions and all operating values of the load device over its service life.

Failure to follow this requirement may lead to unexpected operation of the load device resulting in property damage, injury, and/or death due to train collision or derailment.

5.5.1 Specifications

Table 5–7. CRG Board Specifications

Characteristic	Specification
Maximum number of Boards per VPI System	see assemblies
Board slots required	1
AOCD Current Threshold	3mA
Maximum Board Logic Current Supply	1200 mA

5.5.2 Assemblies

Table 5–8. CRG Board Assembly Differences

Description	Part Number
CRG board assembly for solid state relay code followers; one board per system. Produces codes of 0, 50, 75, 120, 180 pulses per minute.	31166-261-01
CRG board assembly for solid state relay code followers; three boards per system. Produces codes of 0, 50, 75, 120, 180 pulses per minute.	31166-261-03
CRG board assembly for relay code followers; three boards per system. Produces codes of 0, 50, 75, 120, 180, 270, 420 pulses per minute and Steady On	31166-261-04

5.6 IOB (I/O BUS INTERFACE) BOARD P/N 59473-827

The I/O Bus Interface board serves as a buffer between the system processing boards and groups of Vital I/O. It provides a storage medium for test data obtained during Vital input and Vital output port checks. The board includes logic to control the continuous verification of Vital output port states. Each chassis containing Vital input or output boards including the FSVT must have an I/O Bus Interface board.

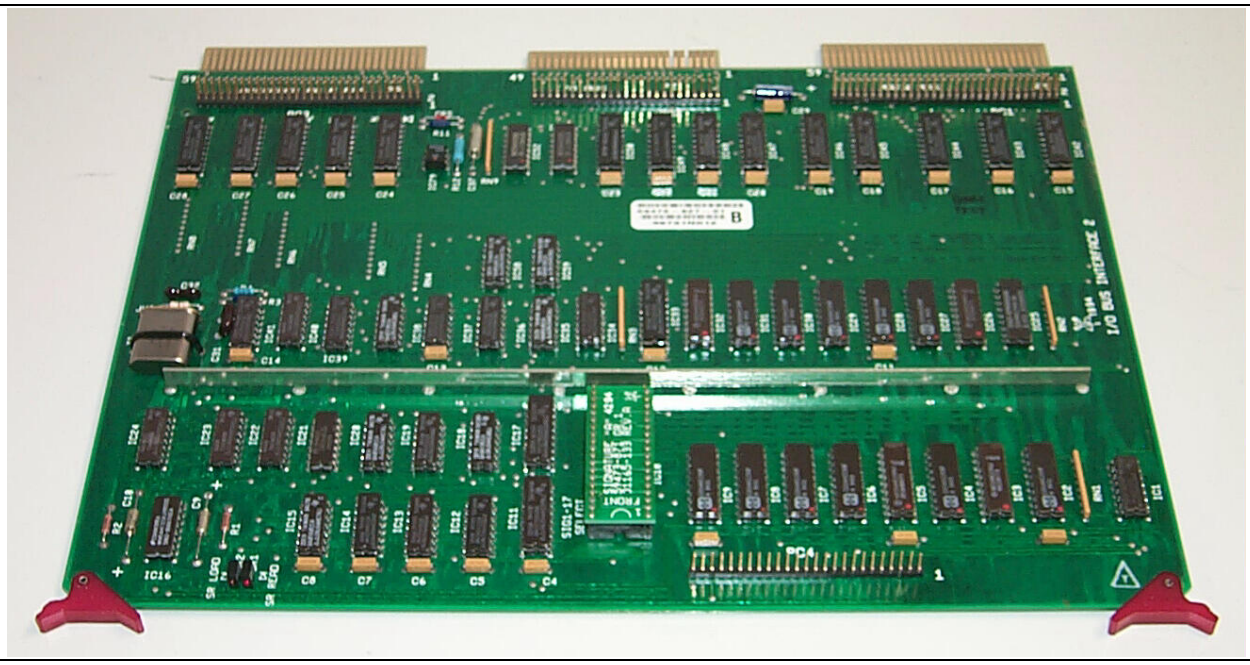

Figure 5-6. I/OB Board

5.6.1 Specifications

Table 5–9. I/O Bus Interface Specifications

Characteristic	Specification
Maximum number of Boards per VPI System	4
Board slots required	1
Maximum Board Logic Current Supply	300 mA
Signature Header 59473-871-01	Board 1
Signature Header 59473-871-02	Board 2
Signature Header 59473-871-03	Board 3
Signature Header 59473-871-04	Board 4

5.6.2 Assemblies

Table 5–10. I/O Bus Interface Assembly Differences

Description	Part Number
I/O Bus Interface	59473-827-01
Signature Header (one for each IOB board in a system)	59473-871-01 through 59473-871-04

5.7 DI (DIRECT INPUT) BOARD P/N 59473-867

Direct Input boards contain 16 isolated Vital inputs that each require two connections to the field (+IN and -IN). The inputs are DC current sensing and require a minimum of 12.8 mA. Two inputs may be connected in parallel with opposite polarity (i.e., input a + connected to input b - and input a - connected to input b +) to form a bipolar input (except for board 59473-867-03).

Note: The input circuits have been designed to interface with circuits that utilize standard, Vital contacts.

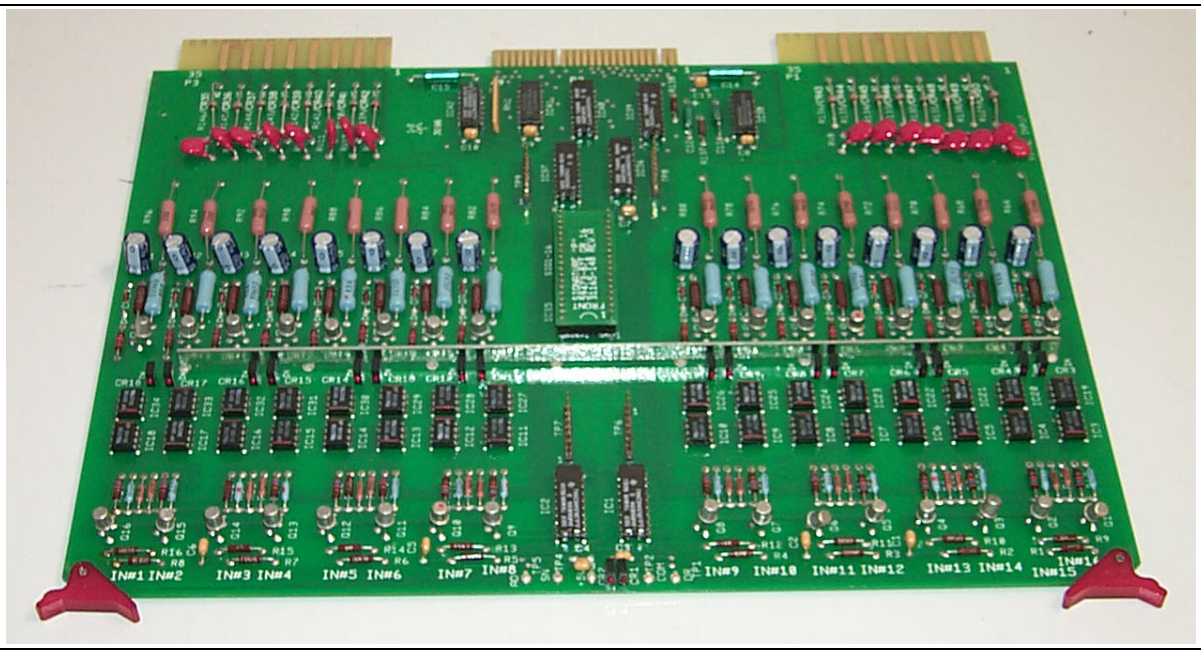

Figure 5-7. DI Board

5.7.1 Specifications

Table 5–11. DI Board Specifications

Characteristic	Specification					
	59473-867-					
	01	02	03	04	05	07
Maximum number of Boards per VPI System	20					
Board slots required	1					
Maximum Board Logic Current Supply	300 mA					
Minimum Input Voltage/Port	9.0 VDC	9.0 VDC	9.0 VDC	45.0 VDC	9.0 VDC	24.0 VDC
Maximum Input Voltage/Port	15.0 VDC	15.0 VDC	15.0 VDC	55.0 VDC	22.0 VDC	34.0 VDC
Input Transient Protection Voltage (Max Voltage)	1700 Vrms					
Input Transient Protection Energy (Max Energy)	3.6 Joules					
Isolation Between Inputs	> 3000 Vrms					
Address Signature Header Required	Yes					
Equipped with Low-Pass Filter	Yes	No	No	Yes	Yes	Yes
Momentary Input Hold	No	No	Yes	No	No	No

5.7.2 Assemblies

Table 5–12. Direct Input Assembly Differences

Description	Part Number
16 Discrete Inputs with Filtering (9 - 15 VDC)	59473-867-01
16 Discrete Inputs w/o Filtering (9 - 15 VDC)	59473-867-02
16 Discrete Inputs with hold circuit (9 - 15 VDC)	59473-867-03[2]
16 Discrete Inputs w/o Filtering (45 - 55 VDC)	59473-867-04
16 Discrete Inputs w/o Filtering (9 - 22 VDC)	59473-867-05
16 Discrete Inputs w/o Filtering (24 - 34 VDC)	59473-867-07
Signature Header (one for each DI board in a system (determined by CAA))	59473-871-01 through 59473-871-16

[2] The 59473-867-03 assembly input circuit possesses the ability to rectify AC signals and is intended for special situations only. Consult Alstom on its use.

5.8 VITAL DC OUTPUT BOARDS P/N 59473-739, -747, -977, -749

There are four types of Vital DC Output boards:

- Single Break: (SBO), 59473-739
- Double Break: (DBO), 59473-747
- Double Break 50 V; (DBO-50V), 59473-977
- Lamp Driver: (LDO), 59473-749

All are configured with eight Vital outputs per board. The single break output is analogous to a single relay contact placed in the positive or feed side of the circuit. The equivalent to the relay contact in the solid state circuit is the FET switch. The double break output is analogous to a relay circuit with the contacts in both the feed and return sides of the circuit. With the solid-state equivalent, however, each output is completely isolated from all other outputs and/or power supplies. The lamp driver's output is equivalent to a single relay contact in the return or common side of the circuit.

All outputs use a circuit (AOCD) that detects current to vitally determine the state of the circuit. If the current is greater than the threshold value, the output is considered in the "ON" state. It is only proven to be "OFF" if the current is less than the AOCD threshold.

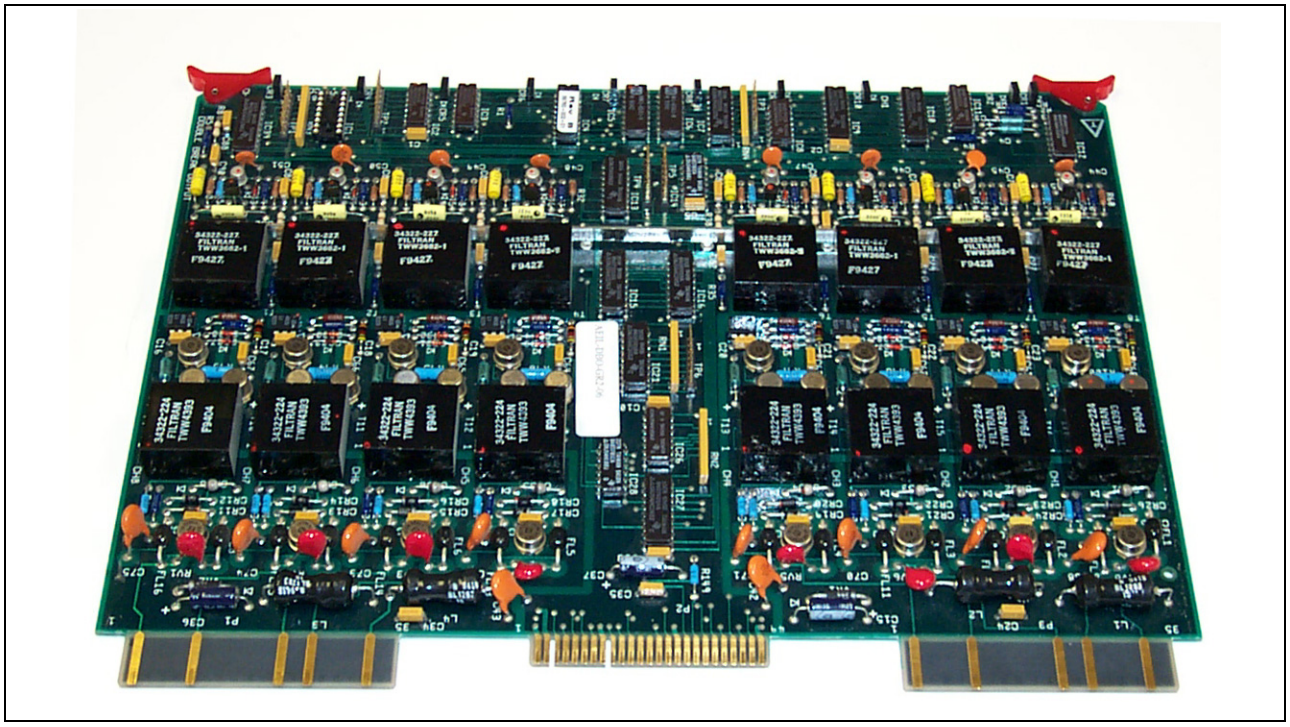

Figure 5-8. Vital Output Boards

5.8.1 SBO Specifications

The single break output is analogous to a single relay contact placed in the positive or feed side of the circuit. The equivalent of the relay contact in the solid-state circuit is the FET switch. This Vital output board is most often used when driving Vital relays that are part of a special network outside of VPI.

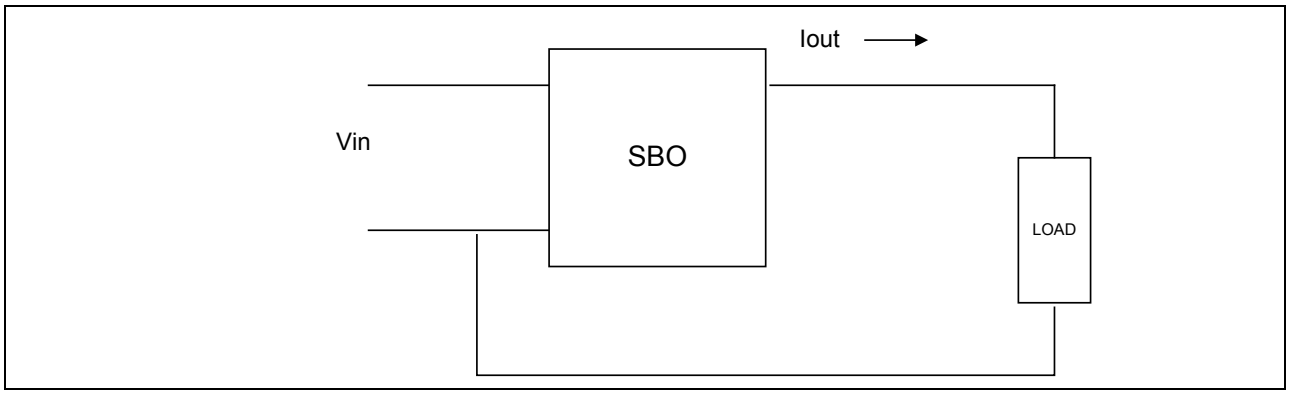

Figure 5-9. SBO Port Interface

WARNING

LOAD DEVICE RESTRICTIONS FOR SINGLE BREAK OUTPUT (SBO) BOARDS

Low current Vital SBO boards may fail with up to 3 milliamperes of output leakage current with the system requesting the output to be in the de-energized state. To prevent a potential unsafe condition, any load device attached to a low current Vital output circuit board must not operate at or below 3 milliamperes and must de-activate above 3 milliamperes. This includes all environmental operating conditions and all operating values of the load device over its service life.

Failure to follow this requirement may lead to unexpected operation of the load device resulting in property damage, injury, and/or death due to train collision or derailment.

Table 5–13. SBO Board Specifications

Characteristic	Specification	
	59473-739-	
	01	02
Maximum Number of Boards Per VPI II System	40	
Board Slots Required	1	
Number of Ports per Board	8	
Maximum Board Logic Current Supply	500 mA	
Minimum Switched Output Supply Voltage (Vin)	9.0 VDC	
Maximum Switched Output Supply Voltage (Vin)	30.0 VDC	
Typical Output Voltage Drop	1.0 VDC	
Maximum Switched Power	15 watts	
AOCD Current Threshold	3 mA	
Maximum Output Current Per Port (Iout)	500 mA	
Isolation Between Outputs and 5 Volt Logic	> 3000 Vrms	
Address Signature PROM Required	Yes	
Code Energy Switching	No	Yes
Group Energy Filtered	Yes	No

5.8.2 Assemblies

Table 5–14. SBO Board Assembly

Description	Part Number
SBO Board Assembly, 8 outputs (9 - 15 VDC) Group energy is filtered	59473-739-01
SBO Board Assembly, 8 outputs (9 - 15 VDC) Group energy is not filtered, supports use of coded energy	59473-739-02
Signature PROM (one for each output board in a system, determined by CAA)	39780-003-01 through 39780-003-40

5.8.3 DBO and DBO-50V Specifications

The double break output is analogous to a relay circuit with the contacts in both the feed and return sides of the circuit. With the solid-state equivalent, however, each output is completely isolated from all other outputs and/or power supplies. Each output is isolated by using individual DC/DC converters that provide in excess of 3000 VRMS isolation. This Vital output board series is used to drive relays, line circuits and most often when a bipolar, i.e., pole change, output is required, e.g., point machine control.

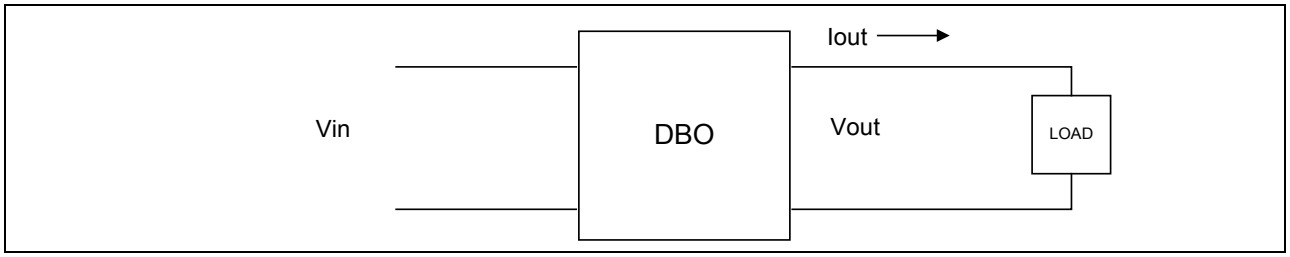

Figure 5-10. DBO Port Interface

WARNING

LOAD DEVICE RESTRICTIONS FOR DOUBLE BREAK OUTPUT (DBO) BOARDS

Low current Vital DBO boards may fail with up to 3 milliamperes of output leakage current with the system requesting the output to be in the de-energized state. To prevent a potential unsafe condition, any load device attached to a low current Vital output circuit board must not operate at or below 3 milliamperes and must de-activate above 3 milliamperes. This includes all environmental operating conditions and all operating values of the load device over its service life.

Failure to follow this requirement may lead to unexpected operation of the load device resulting in property damage, injury, and/or death due to train collision or derailment.

Table 5–15. DBO/DBO-50 Board Specifications

Characteristic	Specification				
	59473-747-			59473-977-	
	01	02	03	01	02
Maximum number of Output Boards per VPI II System	40				
Board slots required	1				
Number of ports per board	8				
Maximum Board Logic Current Supply	500 mA				
Minimum Input Voltage (Vin)	9 VDC	9 VDC	9 VDC	30 VDC	45 VDC
Maximum Input Voltage (Vin)	15 VDC	15 VDC	15 VDC	40 VDC	55 VDC
Minimum Output Voltage (Vout)	6 VDC	17.7 VDC	6 VDC	45 VDC	45 VDC
Maximum Output Voltage (Vout)	15 VDC	34.5 VDC	15 VDC	55 VDC	55 VDC
Maximum Output Current per Port (Iout)	600 mA	300 mA	600 mA	140 mA	140 mA
Maximum Output Power per Port	9 W	9 W	9 W	7.7 W	7.7 W
AOCD Current Threshold	3 mA				
Isolation Between Outputs	> 3000 Vrms				
Signature PROM Required	Yes				

5.8.3.1 Assemblies

Table 5–16. DBO Board Assemblies

Description	Part Number
DBO Board Assembly, 8 outputs (9 - 15 VDC operation) Note: Not for new designs since board keying is the same as that for 747-02 assembly	59473-747-01
DBO Board Assembly, 8 outputs with doubled output voltage (9 - 15 VDC in with 18 - 30 VDC output)	59473-747-02
DBO Board Assembly, 8 outputs (9 - 15 VDC operation) Note: Preferred for new designs since board keying is different than that for 747-02 assembly	59473-747-03
DBO Board Assembly, 8 outputs (30 - 40 VDC operation)	59473-977-01
DBO Board Assembly, 8 outputs (45 - 55 VDC operation)	59473-977-02
Signature PROM (one for each output board in a system, determined by CAA)	39780-003-01 through 39780-003-40

5.8.4 LDO Specifications

The lamp drive output circuit handles high current to light signal lamps. Each output circuit can accommodate hot and cold filament checks. This output uses a FET switch in the common or return line of the circuit. Therefore, it is necessary to supply the positive side of the battery or signal lighting supply to the signal lamps.

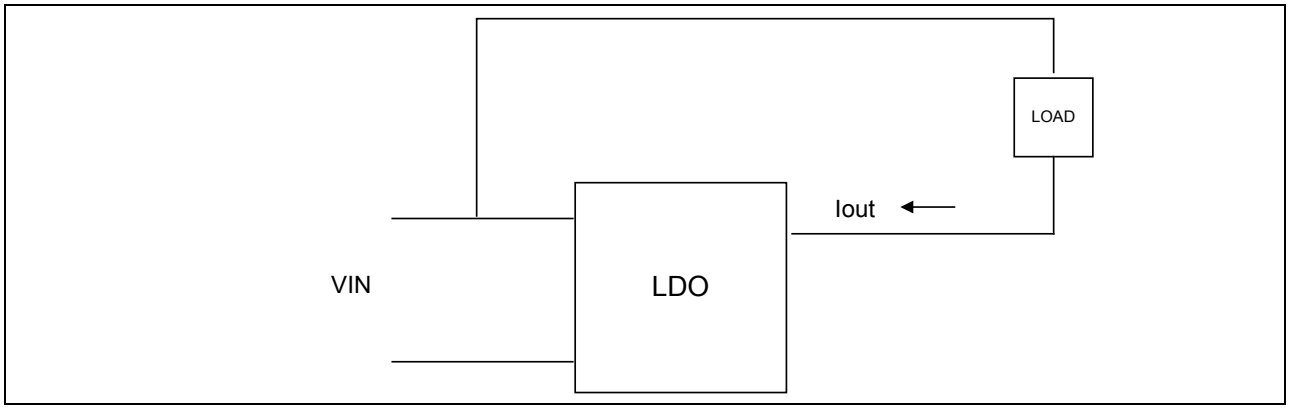

Figure 5-11. LDO Port Interface

WARNING

LOAD DEVICE RESTRICTIONS FOR LIGHT DRIVER OUTPUT (LDO) BOARDS

High current Vital LDO boards may fail with up to 50 milliamperes of output leakage current with the system requesting the output to be in the de-energized state. To prevent a potential unsafe condition, any load device attached to a high current Vital output circuit board must not operate at or below 50 milliamperes and must de-activate above 50 milliamperes. This includes all environmental operating conditions and all operating values of the load device over its service life.

Failure to follow this requirement may lead to unexpected operation of the load device resulting in property damage, injury, and/or death due to train collision or derailment.

Table 5–17. LDO Board Specifications

Characteristic	Specification		
	59473-749-		
	02	03	04
Maximum number of Output Boards per VPI II System	40		
Board slots required	1		
Number of ports per board	8		
Maximum Board Logic Current Supply	500 mA		
Minimum Switched Output Supply Voltage (Vin)	9 VDC	15 VDC	9 VDC
Maximum Switched Output Supply Voltage (Vin)	18 VDC	30 VDC	18 VDC
Maximum Output Current per Port (Iout)	2.0 A	2.9 A	2.9 A
Typical Output Voltage Drop	1.7 VDC		
AOCD Current Threshold	50 mA		
Isolation Between Outputs and 5 Volt Logic	> 3000 Vrms		
Hot/Cold Filament Check	Yes, 100 mA	Yes, 200 mA	Hot 100 mA, no Cold
Signature PROM Required	Yes		

5.8.4.1 Assemblies

Table 5–18. LDO Board Assemblies

Description	Part Number
LDO Board Assembly, 8 outputs (9 - 18 VDC, 2.9 Amp. operation)	59473-749-02
LDO Board Assembly, 8 outputs (15 - 30 VDC, 2.9 Amp. operation)	59473-749-03
LDO Board Assembly, 8 outputs (9 - 18 VDC, 2.9 Amp. operation)	59473-749-04
Signature PROM (one for each output board in a system, determined by CAA)	39780-003-01 through 39780-003-40

5.9 LDO2 SPECIFICATIONS

The LDO2 is a Vital VPI Output board that interfaces with signal lamps. It provides essentially similar functions as the LDO described above. However, this assembly offers the following additional features for each of the eight outputs on each board assembly:

- Sourcing Current Drive (positive side switch)
- Non-Vital Current Monitor with Over Current Protection and Low Current Detection
- Non-Vital Cable Integrity Check (CIC)
- Switch Selectable AOCD Signature PROM

The board assembly together with improved Vital system software offers enhanced CPU-PD diagnostic capability. A diagnostic interface on the board edge is provided to permit maintenance personnel to examine the operation of the board without connecting any other equipment.

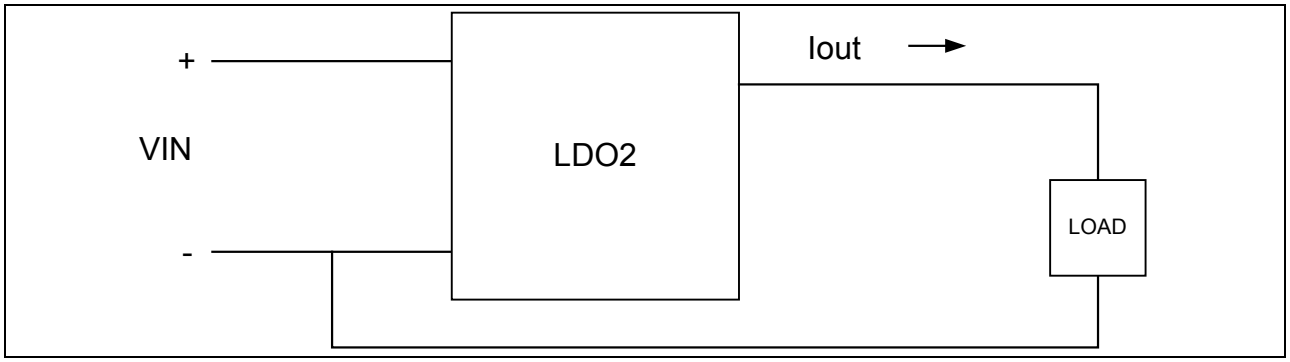

Figure 5-12. LDO2 Port Interface

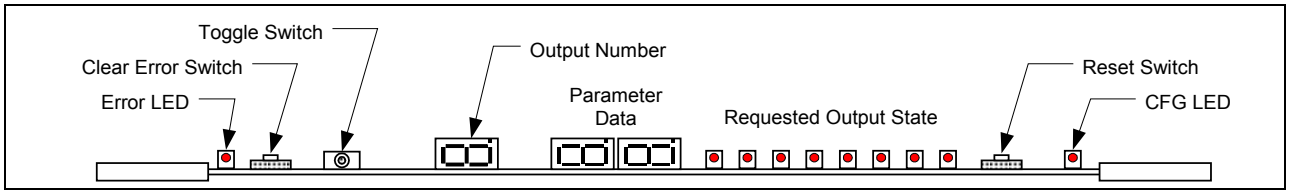

Figure 5-13. LDO2 Board Edge Diagnostic Indicators

WARNING

LOAD DEVICE RESTRICTIONS FOR LIGHT DRIVER OUTPUT 2 (LDO2) BOARDS

High current Vital LDO2 boards may fail with up to 50 milliamperes of output leakage current with the system requesting the output to be in the de-energized state. To prevent a potential unsafe condition, any load device attached to a high current Vital output circuit board must not operate at or below 50 milliamperes and must de-activate above 50 milliamperes. This includes all environmental operating conditions and all operating values of the load device over its service life.

Failure to follow this requirement may lead to unexpected operation of the load device resulting in property damage, injury, and/or death due to train collision or derailment.

Table 5–19. LDO2 Board Specifications

Characteristic	Specification	
	31166-340-	
	01	02
Maximum number of Output Boards per VPI II System	40	
Board slots required	1	
Number of ports per board	8	
Maximum Board Logic Current Supply	350mA	250mA
Minimum Switched Output Supply Voltage (Vin)	8 VDC	
Maximum Switched Output Supply Voltage (Vin)	18 VDC	
Maximum Output Current per Port (Iout)	3.3 A	
Maximum Output Current per 4-port group	7.5 A	
Typical Output Voltage Drop on board	1 V	
Cable Integrity Check Detection Voltage	2.0 ±0.3 V	
Over Current Shutdown Threshold (t = 200 to 400mS)	4.0 A	none
Low level current detection threshold range	0.55 to 3.25 in 7 steps	none
AOCD Current Threshold	50 mA	
Isolation Between Outputs and 5 Volt Logic	> 3000 Vrms	
Hot/Cold Filament Check	Yes, 100 mA	
Signature PROM Required	No	

5.9.1.1 Assemblies

Table 5–20. LDO2 Board Assemblies

Description	Part Number
LDO2 Board Assembly, 8 outputs (8 - 18 VDC, 3.3 Amp. operation)	31166-340-01
LDO2 Board Assembly, 8 outputs w/o current monitor (8 - 18 VDC, 3.3 Amp. operation)	31166-340-02

5.10 ACO (VITAL AC OUTPUT BOARD) P/N 59473-937

The Vital AC Output board operates in a manner similar to Vital Output boards. It is used for lighting signal lamps or for operating other AC loads requiring less than 0.8 ampere.

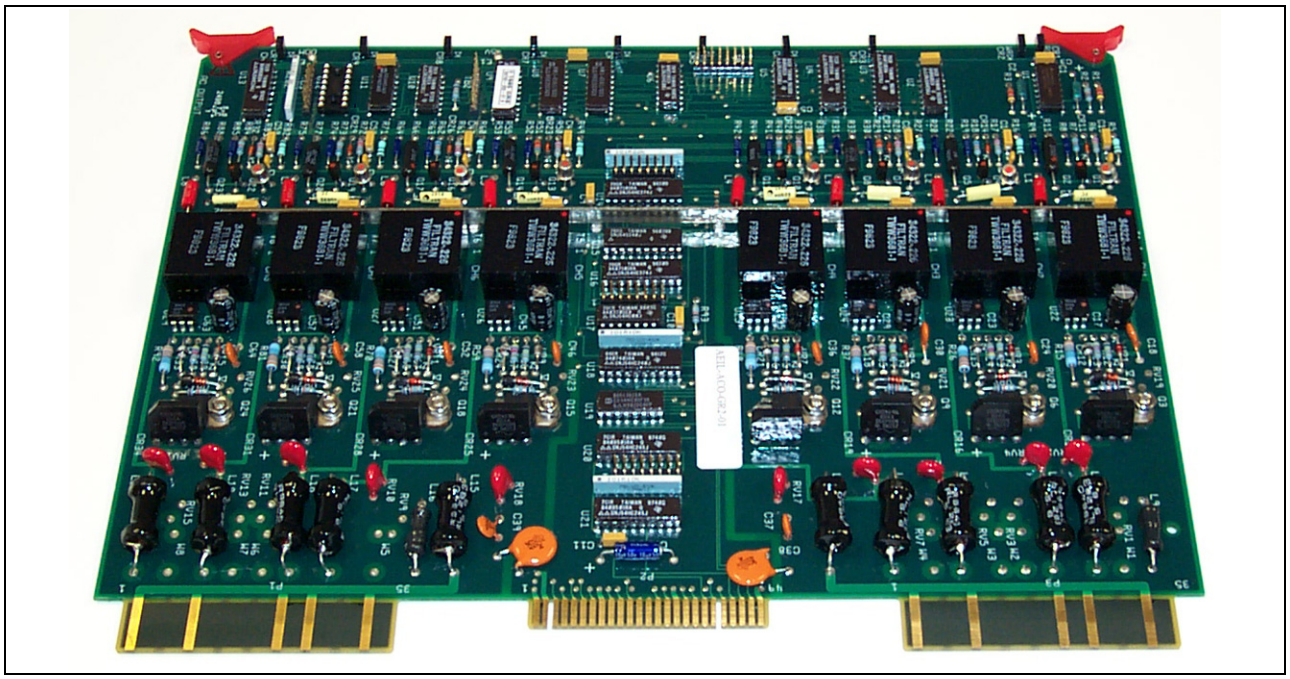

Figure 5-14. ACO Board

5.10.1 Specifications

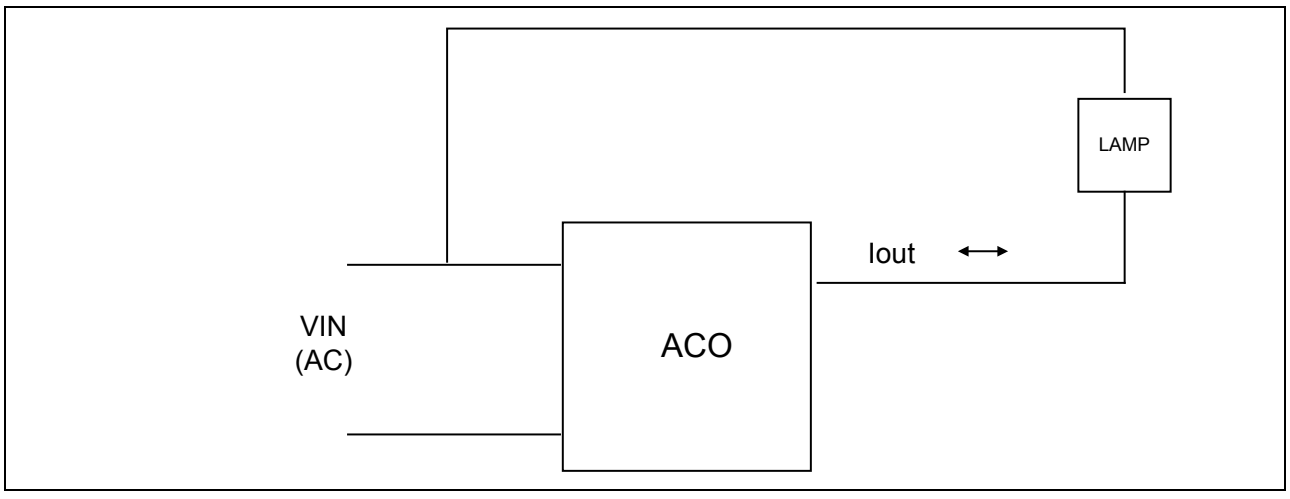

Figure 5-15. ACO Port Interface

WARNING

LOAD DEVICE RESTRICTIONS FOR LOW CURRENT VITAL AC OUTPUT (ACO) BOARDS

Low current Vital AC output boards may fail with up to 3 milliamperes of output leakage current with the system requesting the output to be in the de-energized state. To prevent a potential unsafe condition, any load device attached to a low current Vital output circuit board must not operate at or below 3 milliamperes and must de-activate above 3 milliamperes. This includes all environmental operating conditions and all operating values of the load device over its service life.

Failure to follow this requirement may lead to unexpected operation of the load device resulting in property damage, injury, and/or death due to train collision or derailment.

WARNING

LOAD DEVICE RESTRICTIONS FOR HIGH CURRENT VITAL AC OUTPUT (ACO) BOARDS

High current Vital AC output boards may fail with up to 50 milliamperes of output leakage current with the system requesting the output to be in the de-energized state. To prevent a potential unsafe condition, any load device attached to a high current Vital output circuit board must not operate at or below 50 milliamperes and must de-activate above 50 milliamperes. This includes all environmental operating conditions and all operating values of the load device over its service life.

Failure to follow this requirement may lead to unexpected operation of the load device resulting in property damage, injury, and/or death due to train collision or derailment.

Table 5–21. AC Outputs Specifications

Characteristic	Specification	
	59473-937-	
	02	03
Maximum Number of Boards Per VPI System	40	
Board Slots Required	1	
Number of Ports Per Board	8	
Maximum Board Logic Current Supply	500mA	
Minimum Switched Output Supply Voltage	90 VAC	
Maximum Switched Output Supply Voltage	130 VAC	
Frequency Range	40 - 150 Hz	
AOCD Current Threshold	50 mA	3 mA
Maximum Output Current Per Port	0.8 A rms	0.5 A rms
Switched Power (max resistive)	104 W	
Isolation Between Outputs	> 3000 Vrms	
Special EMI Suppression	No	Yes
Address Signature PROM Required	Yes	

5.10.2 Assembly

Table 5–22. ACO Board Assembly

Description	Part Number
ACO Board Assembly, 8 channels with enhanced EMI protection	59473-937-02
ACO Board Assembly, 8 channels with EMI suppression	59473-937-03
Signature PROM (one for each output board in a system, determined by CAA)	39780-003-01 through 39780-003-40

5.11 FSVT (FIELD-SETTABLE VITAL TIMER) BOARD P/N 59473-894

The Vital Timer board (59473-894) contains provisions for the use of eight field-settable Vital timing functions. Time setting selection is accomplished through the programming of the time selection jumpers. Each of the eight timers has four pin headers that allow setting of the desired time interval by positioning one jumper in each header.

The Vital Timer board is located on the Vital I/O bus. Normal operation is to detect the switch setting and then perform a Vital algorithm to verify the setting of that timer's switch.

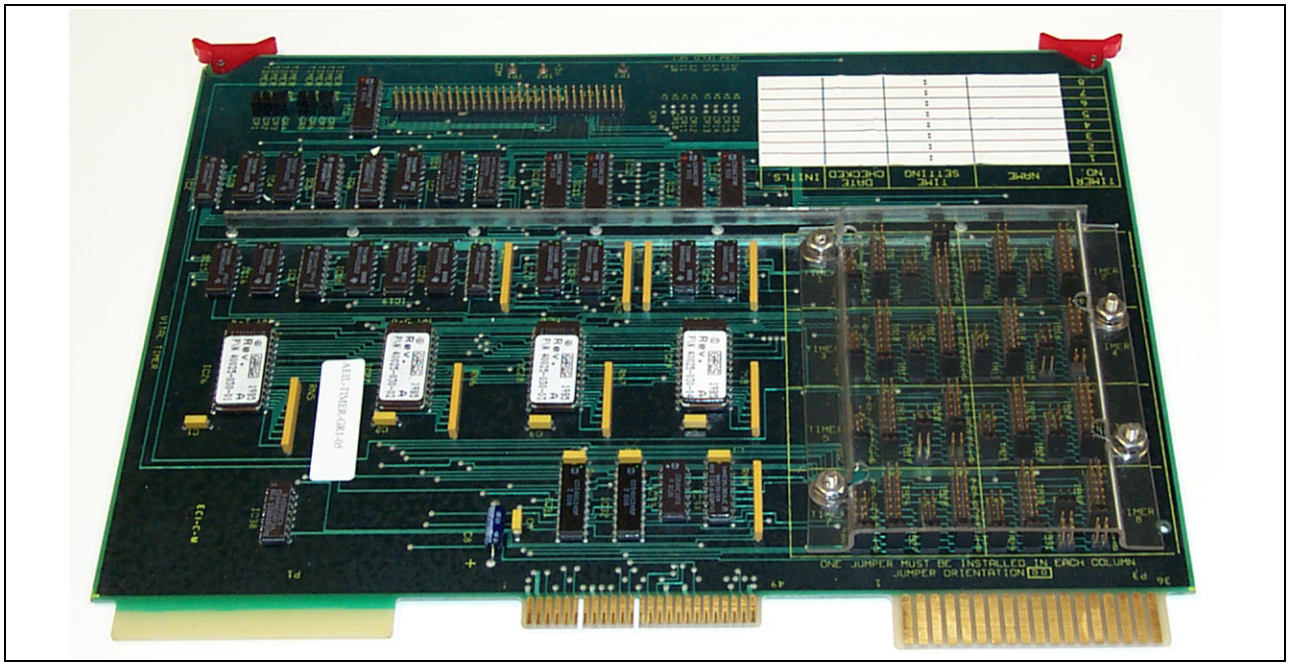

Figure 5-16. FSVT Board

5.11.1 Specifications

Table 5–23. FSVT Board Specifications

Characteristic	Specification	
	59473-894-	
	01	02
Maximum number of Boards per VPI System	2	
Board slots required	1	
Number of Discrete Timers per board	8	
Used for Vital Timers Number	1 through 8	9 through 16
Minimum Run Time (minutes/seconds)	0:00	
Maximum Run Time (minutes/seconds)	59:59	
Assign to I/O Bus With Signature Header Drawing No. (ID letter)	59473-871-01 (A)	
Jumper TB4 Timer Settings (min/max units seconds)	00/09 seconds	
Jumper TB3 Timer Settings (min/max tens seconds)	0/50 seconds	
Jumper TB2 Timer Settings (min/max units minutes)	00/09 minutes	
Jumper TB1 Timer Settings (min/max tens minutes)	0/50 minutes	
Time Setting Method	Jumper Selection	

5.11.2 Assemblies

Table 5–24. FSVT Assembly Differences

Description	Part Number
Eight timers for timers one through eight	59473-894-01
Eight timers for timers nine through sixteen	59473-894-02

5.12 APPLICATION ASSUMPTIONS AND CONSTRAINTS

Several assumptions have been defined to be used in the application of the generic product and are included here along with any associated product constraints.

5.12.1 Application Assumption/Requirements

5.12.1.1 System Cycle

VPI is based on a defined and vitally verified one-second cycle where all inputs, evaluations, and outputs are provided.

5.12.1.2 Vital Timing

Application timing is provided based on increments of the vitally ensured VPI one-second system cycle.

5.12.1.3 System Grounding

VPI's internal logic power supply is internally connected to a ground plane, subsequently to the electronics chassis, and, finally, through an external connection to "earth" through proper RFI friendly cables. Typically this is performed by connecting a shielded cable from the equipment rack in which VPI is mounted to the earth common reference in the equipment room. This grounding is maintained to "shunt" induced RFI away from critical I/O circuits and prevent disruption to system processing. This "earth ground" must be considered when providing connections between VPI I/O and field devices in order to insure that the earth ground remains isolated from the signaling battery.

5.12.1.4 Vital Inputs

Inputs that are considered Vital are expected to be provided by a Vital source such that:

- permissive inputs (ON) will be presented as DC signals at the level of the Vital signaling battery (with some tolerance), or
- restrictive inputs (OFF) will be presented as no voltage (0 volts)
- there is no defined threshold for OFF beyond the assumption that no energy is applied (0 VDC, no connection) or there is no presence of voltage signifying ON at signal battery + voltage level
- while VPI performs input scanning with detection of induced AC (25–250 Hz), proper care must be taken in the installation layout of wiring so that no differentially induced AC signal can be presented to a Vital input where the level of this input could be inappropriately sensed as a permissive state (>3 VDC)

5.12.1.5 Response Time to a Safety Critical Failure

VPI has been designed to remove output energy when a failure is detected prior to the period required to have a switch (point) machine begin to move from its intended position (normal or reverse) or to energize a traditional B-Relay (<200 ms). This is considered the worst case safety failure. VPI's design maintains a failure detection to energy removal period of 140 ms.

Switch machines or other signaling devices that complete state change in less than 200 ms, such as air operated switch machines, must not be directly interfaced to a VPI system without a Vital relay between the VPI and the machine to introduce a sufficiently delayed response.

5.12.1.6 Signaling Logic Ordering

VPI evaluates logic in a sequential manner from first expression to last each system cycle. When implementing signaling rules, this fact must be considered to insure proper order of output states and proper sequences of rules implementation.

5.12.1.7 Vital Output Verification

VPI's detection of failures on outputs is accomplished through the detection of current flow in an output that has been otherwise directed to be in the OFF state. Absence of current in an OFF output is positive proof that no failure has occurred to falsely drive that output. The detection threshold on the absence of current detector is any current over 3 ma for DC non-signal output types and 100 ma for signal lamp drivers. Therefore, when designing an interlocking application, it must be guaranteed that VPI output loads will draw more than 5 ma (150 ma) of current during normal operation when the output is turned ON to provide safe operating margin.

5.12.1.8 Preventing Potential Output Circuit Run-Around Paths (Vital Outputs)

VPI outputs have been designed for single break (SBO, ACO, LDO) and double break (DBO) application. When designing equipment room and field wiring, care must be taken when using single break outputs so that external failures such as shorted wires cannot introduce a run-around path for output current that could energize an output that should be in the OFF state.

5.12.1.9 Safety Checks Outputs

In order to achieve required response time, physical output states (for OFF outputs) and Logic expression results (for ON outputs) are verified every 50 ms.

5.12.1.10 Safety Checks System Processing

Verification of system processing checks such as memory integrity, Vital timing, etc., is accomplished once each system's one-second cycle.

5.12.1.11 Application Verification

WARNING

INTENDED SAFE FUNCTIONALITY OF THE VPI SYSTEM MUST BE VERIFIED

The safety of the application logic as written is the responsibility of an experienced signal engineer—CAAPE does not make any determination regarding the inherent safety of the logic equations that were entered.

Verifying the accuracy with which CAAPE converted the signaling engineer's application data into PROM data structures is aided by CAAPE, but the signaling engineer must make a final determination using information supplied by CAAPE. CAAPE's compilers are not themselves Vital programs. An additional independent process is needed to verify that the compile was done correctly. This process is required for all Vital applications.

An experienced signal engineer must verify the safety of the VPI data and its application. It is the signaling engineer's responsibility to verify the correctness of the VPI input data in that it accurately represents the intended safe functionality of the VPI system. Furthermore, "verify the correctness" means that the signaling engineer (1) is required to compare the input and output data files to verify the CAA has operated correctly and (2) must test the VPI application in its intended environment before it can be placed in revenue service.

Failure to comply can degrade the safety performance of the train control system resulting in property damage, injury, and/or death due to train collision or derailment.

WARNING

VPI APPLICATION MUST BE VALIDATION TESTED

Prior to revenue service, validation testing must confirm all VPI application logic is correct and consistent with application requirements.

Failure to comply can degrade the safety performance of the train control system resulting in property damage, injury, and/or death due to train collision or derailment.

The basis of the application of VPI is to use a tool to configure the system hardware and software as well as create the signaling logic for the Vital application. The independent Application Data Verifier Tool, as well as associated procedures, must be run and performed prior to any VPI application program being tested in field commissioning tests.

5.12.1.12 Output Current Check for Output Ports

VPI has the ability to vitally determine current flow in an output port. This parameter can be used as an internal parameter in the building of the signaling logic rules. This feature is only available for DC-based outputs. AC outputs that are turned ON cannot take advantage of the Vital current check feature, as the check mechanism cannot produce an expected result due to the unsynchronized nature of the output check and the positive voltage peak of the AC cycle.

5.12.1.13 Cycles of Forgiveness

Vital inputs, because they are not synchronized to the system cycle, can be sensed to be in an unknown state during transition from ON to OFF, or due to spurious interference to an ON input. This is not a safety-critical issue. A feature termed “cycle of forgiveness” (COF) can be applied to inputs to prevent either of the two input sensing situations from having an undesirable ripple effect on signaling logic. The COF can be used to delay response to a transitional input for a given system cycle. Care must be taken to analyze the overall system response time when COF are assigned to inputs.

5.12.1.14 Proof of Logic (Primordial Logic Review)

WARNING

ADV INPUT DATA MUST BE VERIFIED SEPARATELY—PRIOR TO ADV PROCESS

Vital system operation requires that the Boolean equations in the Vital application logic must be written correctly, so that by executing the logic, the VPI system operates safely in accordance with the rules of the transit or railroad authority.

The Application Data Verifier (ADV) output report provides a means to compare and verify equivalence between the input and the output application data.

However, the Application Data Verifier neither determines the safety suitability of the Boolean expression list nor determines the validity of certain encoded VPI application data. The input data to the ADV process must be verified for safety separately, prior to the ADV process, and the safety and suitability of the input data is the responsibility of the signaling engineer.

The ADV does, however, issue warnings and error messages as a result of non-vital data checking to alert the signaling engineer to possible discrepancies.

Failure to comply can degrade the safety performance of the train control system resulting in property damage, injury, and/or death due to train collision or derailment.

WARNING

VPI APPLICATION MUST BE FIELD TESTED

Field testing of a VPI application is required before placing the location into revenue service. The customer's testing plan and safety plan define the testing requirements for the VPI application.

Failure to comply can degrade the safety performance of the train control system resulting in property damage, injury, and/or death due to train collision or derailment.

WARNING

VERIFIER MUST BE DIFFERENT THAN DESIGNER

The signaling engineer responsible for verification (the Checker or Verifier) using the ADV checklist and creating the report shall be independent from the signaling engineer responsible for designing (the Designer) the VPI application.

Failure to comply can degrade the safety performance of the train control system resulting in property damage, injury, and/or death due to train collision or derailment.

The application of VPI depends on application engineers defining configurations and logic to be implemented for the interlocking application. While VPI guarantees that logic and outputs, etc., are managed vitally, there is no intrinsic check on the correctness or completeness of the signaling logic as it is intended to meet the requirements of the transit/railroad application. It is a primary safety requirement that the logic produced for VPI execution be independently verified as correct and complete through a “circuit check” type process. The check process must be performed by engineers knowledgeable in the requirements of the signaling rules that govern transit/railroad operation and independent from the engineering staff that produced the logic.

5.12.1.15 Short Cycle Timer Protection

WARNING

TIMER EQUATION PROTECTION REQUIRED

Vital Boolean and timer equations are evaluated in every one-second application cycle regardless of the state of the VRD, therefore every timer equation must include the VRDFRNT-DI vital input as a constituent in order to prevent the timer from running short and completing an evaluation of the equations prematurely.

Failure to comply can degrade the safety performance of the train control system resulting in property damage, injury, and/or death due to train collision or derailment.

All VPI timer equations should include a VRDFRNT-DI parameter to ensure that the timing cannot be “short-timed.” Protection of system timing is provided by check results each one-second timing cycle. Failure of a timer, runs short, would be detected and drop the VRD. However, timing equations continue to evaluate, and therefore a timer equation could prematurely complete. By inserting the VRDFRNT-DI input into a timer equation this situation can be prevented.

5.12.1.16 Output Protection

WARNING

PROTECT VITAL OUTPUT EQUATIONS WITH VRDFRNT-DI

Relying on the status of the VRDFRNT-DI Vital input to, in effect, control Vital output devices without including the VRDFRNT-DI Vital input in the respective output equations does not provide fail-safe operation. The VRDFRNT-DI Vital input must be used as a constituent to the Vital output Boolean equations.

Failure to comply can degrade the safety performance of the train control system resulting in property damage, injury, and/or death due to train collision or derailment. Customer Application of VRDFRNT-DI in a non-vital manner is done so at the risk managed by the customer (Alstom Signaling takes no responsibility for that risk).

The primordial logic should be designed to assure that failures in internal and external circuitry, including the VRD Relay and VRD Repeater Relays, result in known safe conditions. All VPI output control equations should be evaluated by a capable and qualified user (e.g., experienced signal engineer) to include a VRDFRNT-DI parameter to ensure that all outputs, for example signals and vital serial parameters, are placed in a restrictive state in the event of a system failure including a failure in the VRD Relay or VRD Repeater Relay circuitry external from the VPI system.

5.12.1.17 VRD Relay and VRD Repeaters

WARNING

USE OF LRUS NOT MANUFACTURED BY ALSTOM

Alstom strongly recommends only using Lowest Replaceable Units (LRUs) manufactured by Alstom in order to maintain the safe operation of the train control system. Use of LRUs not manufactured by Alstom in the Alstom train control system can degrade the safety performance of the system resulting in property damage, injury, and/or death due to train collision or derailment.

Alstom strongly recommends that a detailed AREMA-compliant safety analysis be performed before using any LRU that is not an Alstom manufactured direct replacement for this Alstom train control system. This safety analysis should be performed by personnel with mastery in the system safety implications of using LRUs not manufactured by Alstom.

Responsibility for the adequacy of the safety analysis rests solely with the transit or railroad authority and Alstom will neither review nor approve any such safety analysis.

For train control systems designed by Alstom, the transit or railroad authority shall be solely responsible for any consequences to the safety integrity and performance of the train control system in which LRUs not manufactured by Alstom are used in the train control system originally designed, safety certified, and commissioned by Alstom. Alstom assumes no responsibility or liability for the safe performance of the train control system once LRUs not manufactured by Alstom are used.

For train control systems not designed by Alstom, the transit or railroad authority shall be solely responsible for any consequences to the safety integrity and performance of the train control system in which LRUs not manufactured by Alstom are used. Alstom assumes no responsibility or liability for the safe performance of the train control system once LRUs not manufactured by Alstom are used.

WARNING

USE OF LRUS NOT REPAIRED BY ALSTOM

Alstom strongly recommends all LRU repairs be performed by Alstom as Alstom uses special components and has developed special assembly and repair techniques to ensure the continued safety of the train control system. Use of LRUs not repaired by Alstom in the Alstom train control system can degrade the safety performance of the system resulting in property damage, injury, and/or death due to train collision or derailment.

Alstom strongly recommends that a detailed AREMA-compliant safety analysis be performed before using any LRU not repaired by Alstom in this Alstom train control system. This safety analysis should be performed by personnel with mastery in the system safety implications when using Alstom LRUs not repaired by Alstom.

Responsibility for the adequacy of the safety analysis rests solely with the transit or railroad authority and Alstom will neither review nor approve any such safety analysis.

For train control systems designed by Alstom, the transit or railroad authority shall be solely responsible for any consequences to the safety integrity and performance of the train control system in which LRUs not repaired by Alstom are used in the train control system originally designed, safety certified, and commissioned by Alstom. Alstom assumes no responsibility or liability for the safe performance of the train control system once LRUs not repaired by Alstom are used.

For train control systems not designed by Alstom, the transit or railroad authority shall be solely responsible for any consequences to the safety integrity and performance of the train control system in which LRUs not repaired by Alstom are used. Alstom assumes no responsibility or liability for the safe performance of the train control system once LRUs not repaired by Alstom are used.

WARNING

USE ONLY ALSTOM VITAL RELAY WITH VRD BOARD

Only Alstom VRD relay (P/N 56001-787-05) is to be used with the Alstom VPI system VRD circuit board. Alstom products are designed to function within all-Alstom systems. The introduction of non-Alstom products into an Alstom VPI system could have unintended and unforeseeable safety consequences.

Failure to comply can degrade the safety performance of the train control system resulting in property damage, injury, and/or death due to train collision or derailment.

The VPI VRD relay is a specific type as it forms the final stage of the Vital circuit residing on the VPI VRD circuit board. Its pick time and pick-up and drop-away currents are critical parameters in guaranteeing a quick response to a detected failure.

The VRD relay is used to disconnect output energy should VPI encounter a failure in a Vital process, result, or output state. Back contacts of the VRD relay are typically used to drive the Red Aspect of signals to show a positive Stop aspect rather than a dark signal. In large locations, it may be necessary to use a repeater in order to take advantage of the additional contacts for signal lighting.

VRD repeaters may also be used to distinguish between feeding output groups from different signaling supply sources.

Where either of these situations requiring repeater relays is considered, a response time review should be performed to insure that the added drop times of the repeater relays do not delay the response to a failure detected by VPI. Depending on repeaters used and arrangement, response time greater than 140 ms will likely be observed.

5.12.1.18 Simultaneous Failures

Two or more independent self-revealing component failures will not occur simultaneously. This assumption has been traditionally accepted in the train signaling industry. There are three aspects of the assumption, however, which should be emphasized.

- The first is the aspect of “independent failures.” Failure modes of individual components may be interrelated in such a way that one failure may precipitate others. These interrelated failures would then constitute one “independent” failure.
- The second aspect is that of simultaneity. “Simultaneously” in this context means “during the period bounded by the occurrence of the first independent self-revealing failure and the occurrence of the event which reveals that failure.”
- The third aspect is that the maximum component failure rate should be low enough to preclude “simultaneous” failures.

5.12.1.19 FMEA Provides Adequate Failure Coverage

The Failure Modes and Effects Criticality Analysis technique, correctly and comprehensively applied, is adequate to reveal all potential unsafe effects of component failure. Justification of this assumption is again based on accepted industry practice (i.e., AREMA).

5.12.1.20 Security of Installation

In order to maintain security from physical tampering, VPI is required to be installed within either an enclosed case (under lock and key) or a locked equipment house where only those trained in the line maintenance or designated members of the rail authority have necessary means of access.

5.12.2 Maintenance Assumption

5.12.2.1 External Input/Output Integrity

VPI Vitally insures that any safety critical failure that occurs internal to the system (inboard side of the electrical boundaries of its input and output circuit boards) is detected with the system attaining a more restrictive state should a failure occur. VPI does not have the capability to determine if an erroneously applied energy (positive Vital signal battery voltage) has been applied to its input. In a similar manner, VPI cannot detect if energy has been erroneously applied to an output drive circuit external to the system thereby supplying a potentially more permissive output state than VPI has calculated. It is assumed that proper maintenance is being provided by the rail authority to prevent instances of signal circuit shorts which could produce such an occurrence.

5.12.2.2 Site Version/Revision Configuration Control

WARNING

SOFTWARE REVISION CONTROL MUST BE MAINTAINED

Failure to properly version control VPI system software and VPI application data can result in unintended consequences including train derailment, train collision, personal injury, and/or death.

Alstom strongly recommends that strict revision control of the VPI application data and system software be maintained so that the expected configuration in the train control system is the actual installed configuration.

For train control systems designed by Alstom, the transit or railroad authority shall be solely responsible for any modifications whatsoever to the train control system which deviate from Alstom's originally delivered design, and any consequences to the system's safety integrity and performance as a result of such modifications. Alstom assumes no responsibility or liability for any modifications to the train control system or for the safe performance of the train control system once Alstom's originally delivered design has been modified.

For train control systems not designed by Alstom, the transit or railroad authority shall be solely responsible for the design of the train control system, and any consequences to the system's safety integrity and performance as a result of such designs. Alstom assumes no responsibility or liability for any designs or for the safe performance of the train control system.

WARNING

UNIQUE SITE ID CONTROL MUST BE MAINTAINED

Failure to properly assign, maintain and control unique Site IDs for VPI systems can result in unintended consequences including train derailment, train collision, personal injury, and/or death.

Alstom strongly recommends that strict control of the Site IDs be maintained so that the expected configuration of all VPIs in the train control system is the actual installed configuration.

For train control systems designed by Alstom, the transit or railroad authority shall be solely responsible for any modifications whatsoever to the train control system which deviate from Alstom's originally delivered design, and any consequences to the system's safety integrity and performance as a result of such modifications. Alstom assumes no responsibility or liability for any modifications to the train control system or for the safe performance of the train control system once Alstom's originally delivered design has been modified.

For train control systems not designed by Alstom, the transit or railroad authority shall be solely responsible for the design of the train control system, and any consequences to the system's safety integrity and performance as a result of such designs. Alstom assumes no responsibility or liability for any designs or for the safe performance of the train control system.

WARNING

ACCURATE SOFTWARE REVISION ID CONTROL MUST BE MAINTAINED

Failure to update and maintain the Software Revision IDs for **every** software change made to the VPI application data and/or system software (even a re-compile done with no software changes) jeopardizes proper software revision control and can result in unintended consequences including train derailment, train collision, personal injury, and/or death.

Alstom strongly recommends that Software Revision IDs be changed with **every** software change, even a re-compile of unchanged software. Software Revision IDs shall be maintained so that software and application revision control is maintained and the expected configuration of all VPIs in the train control system is the actual installed configuration.

For train control systems designed by Alstom, the transit or railroad authority shall be solely responsible for any modifications whatsoever to the train control system which deviate from Alstom's originally delivered design, and any consequences to the system's safety integrity and performance as a result of such modifications. Alstom assumes no responsibility or liability for any modifications to the train control system or for the safe performance of the train control system once Alstom's originally delivered design has been modified.

For train control systems not designed by Alstom, the transit or railroad authority shall be solely responsible for the design of the train control system, and any consequences to the system's safety integrity and performance as a result of such designs. Alstom assumes no responsibility or liability for any designs or for the safe performance of the train control system.

WARNING

UNIQUE SYSTEM ID CONTROL MUST BE MAINTAINED

Failure to properly assign, maintain and control a unique System ID for each VPI system within the entire train control system can result in unintended consequences including train derailment, train collision, personal injury, and/or death.

Alstom strongly recommends that strict control of the System IDs be maintained so that the expected configuration of all VPIs within the entire train control system is the actual installed configuration.

For train control systems designed by Alstom, the transit or railroad authority shall be solely responsible for any modifications whatsoever to the train control system, which deviate from Alstom's originally, delivered design, and any consequences to the system's safety integrity and performance as a result of such modifications. Alstom assumes no responsibility or liability for any modifications to the train control system or for the safe performance of the train control system once Alstom's originally delivered design has been modified.

For train control systems not designed by Alstom, the transit or railroad authority shall be solely responsible for the design of the train control system, and any consequences to the system's safety integrity and performance as a result of such designs. Alstom assumes no responsibility or liability for any designs or for the safe performance of the train control system.

One hazard condition that needs to be considered with regard to software-based interlocking control is the potential of installing an old and incorrect release or that of a similar application program other than the one required. This could occur through improper maintenance activities following system failure. One of the mitigations of this class of failure has been to institute location (site) and revision control features into VPI. The site and revision ID must be uniquely assigned by the Application Engineer with each interlocking program change that will be installed in a field location.

Note: For CPU/PD, refer to the application .lvc file for the wire table in order to configure the hardware jumper wires for the compiled revision and site ID values. Alternatively, refer to the application .cfg file for the System ID. The System ID is equivalent to the combination of the Revision ID and Site ID. The System ID board can be configured with the compiled System ID value.

VRD will not energize if the Revision ID/Site ID/System ID values configured on the hardware do not match the values configured in the CPU/PD application.

5.12.3 Production Assumptions

5.12.3.1 System Manufacturing

VPI has been designed with the latest state of the art surface mount components and has been fully qualified to international rail industry standards as well as quality standards for complete system component manufacture. It is assumed that the manufacturer of printed circuit boards continues to follow recommended production standards for printed circuit boards and that it is periodically verified though quality inspection that proper production and handling best practices have been performed.

It is further assumed that Alstom will be made aware of any change to components, or manufacturing processes of Vital printed circuit boards prior to authorization being given to proceed with the changes. This includes first run production as well as printed circuit boards being cycled through a repair cycle.

5.12.4 External Interface Assumptions

5.12.4.1 I/O Interface

It needs to be considered that VPI inputs must not be connected to any external device that can act to rectify an induced AC signal. Inputs that are not static in nature (i.e., ON/OFF), such as dynamic signals, must be reviewed for Vital application.

5.12.4.2 Vital Serial Links

VPI provides a Vital communication protocol called Vital Serial Link (VSL). VSL establishes communications over a direct-connect copper interface or through an EIA232 interface with a modem or multiplexer. It must be understood that the Vital protocol established has taken into account all known hazards associated with the medium of communications, as well as the interconnection of various adjacent VPI, VPI II, and track circuit systems that reside on the medium. The protocols require that the receiving system must perform the final verification of the message Vital integrity. Connection to other systems requires a thorough review of safety methods used on both sides of the interface to insure that all protections provided for in the VSL protocol are maintained.

5.12.4.2.1 Vital Serial Link Message Identification

WARNING

VITAL COMMUNICATIONS REQUIRE UNIQUE LINK AND BLOCK SETTINGS

Failure to properly assign, maintain and control unique Link and Block settings for Vital communications within VPI systems can result in unintended consequences including train derailment, train collision, personal injury, and/or death.

The message link and block values must be assigned such that the combination of these values is unique throughout the network.

Alstom strongly recommends that strict control of the Link and Block settings be maintained so that the expected configuration of all VPIs in the train control system is the actual installed configuration.

For train control systems designed by Alstom, the transit or railroad authority shall be solely responsible for any modifications whatsoever to the train control system which deviate from Alstom's originally delivered design, and any consequences to the system's safety integrity and performance as a result of such modifications. Alstom assumes no responsibility or liability for any modifications to the train control system or for the safe performance of the train control system once Alstom's originally delivered design has been modified.

For train control systems not designed by Alstom, the transit or railroad authority shall be solely responsible for the design of the train control system, and any consequences to the system's safety integrity and performance as a result of such designs. Alstom assumes no responsibility or liability for any designs or for the safe performance of the train control system.

The VSL messages must be unique in order to assure safe communications; supported by the assignment of link and block/sub-block numbers. The message link and block/sub-block values must be assigned such that the combination of these values is unique throughout the network.

The VSL protocol does not protect against spoofing and the user must maintain a private communications network.

5.12.5 Miscellaneous Assumptions

5.12.5.1 EMC-EMI

The nature of the modifications for VPI in comparison to VPI, are not subject to downgrade original EMC / EMI characteristics. VPI rack as an incremental evolution of the mature VPI has been tested and qualified to AREMA 11.5.1 Class C Standard. However, this document refers to the executed test on the generic VPI-VPI2-iVPI Products, i.e., VPI-VPI2-iVPI rack, EMC-EMI shall be verified in the frame of each Application Project with:

- specific control room power supply characteristics, protection and filter where the VPI-VPI2-iVPI rack in installed
- specific cubicle project configuration
- specific cubicle wiring
- specific cubicle and grounding
- etc.

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SECTION 6 – NON-VITAL SUBSYSTEM

6.1 GENERAL

This section describes the non -vital boards and assemblies used in the VPI system.

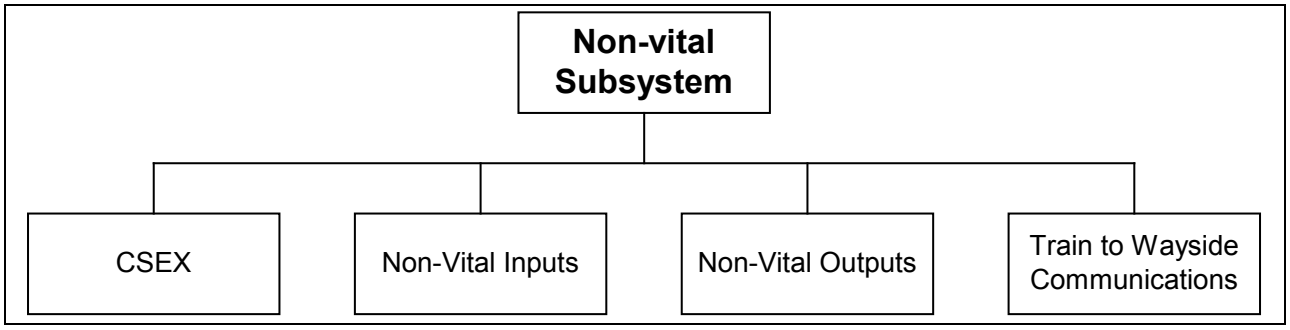


Figure 6-1. Non-Vital System

WARNING

NON-VITAL SUBSYSTEM IS NOT FAIL-SAFE

The non-vital subsystem and communications software used in the VPI system is not designed for fail-safe application and must not be used for safety-critical operations.

Failure to comply can degrade the safety performance of the train control system resulting in property damage, injury, and/or death due to train collision or derailment.

6.2 NON-VITAL PROCESSOR FAMILY (NVP)

The non-vital processors perform important communications, data logging and non-vital logic operations within the VPI system. There have been three generations of processor boards with generally increasing functionality. All the non-vital processors are referred to as CSEX which stands for Code System Emulator eXtended. The first CSEX board family was the 59473-938 series. This board was developed to support multiple, non-vital communications links simultaneously and to permit the separation of the non-vital application from the Vital to better support the non-vital application requirements. The CSEX2 board family, 31166-049, enhanced the flexibility of configuration of the non-vital communications interfaces and the first generation of data logging. The latest family, CSEX3, 31166-175, was designed to support larger, more demanding non-vital applications and provided a greater depth of memory for data logging. The CSEX3 was also designed to be a plug-in replacement for either the earlier CSEX or CSEX2 board assemblies.

6.2.1 CSEX3 (Extended Code System Emulator 3) Board P/N 31166-175

The CSEX3 (Code System Emulator eXtended) board is an upgrade for both the CSEX (59473-938) and CSEX2 (31166-049) boards. It is designed as a system board for VPI as well as a stand-alone non-vital logic processor. The CSEX3 board has six serial ports for communications to external devices, such as modems, other CSEX boards, etc. A 80C186 microprocessor (20Mhz). A DC code line interface is available as well as EIA232, EIA422, and EIA485 interfaces. The CSEX3 board provides an interface to non-vital inputs and outputs for local control of interlockings. Battery-backed RAM is also available for data logging. The CSEX3 board is designed using primarily SMT (Surface Mount Technology) parts. CSEX3 supports up to 20 NVIO boards. This board is extensible to support interfaces with various LAN and WAN networking protocols.

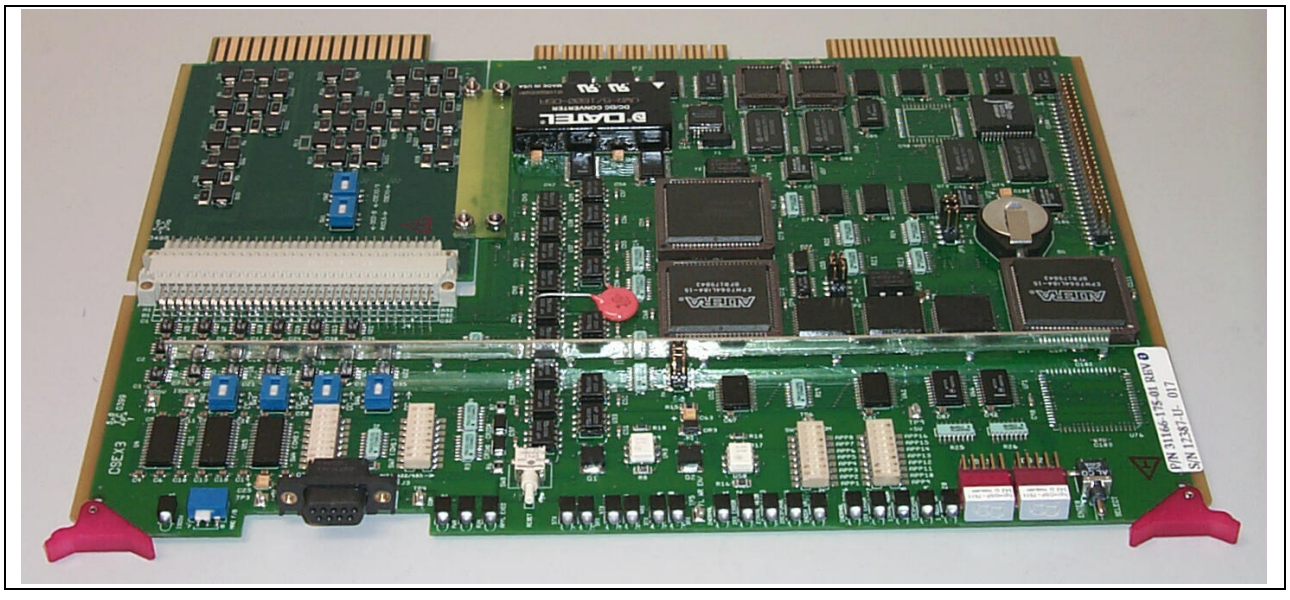


Figure 6-2. CSEX3 Board

6.2.1.1 Specifications

Table 6–1. CSEX3 Board Specifications

Characteristic	Specification	
	31166-175-	
	02	03
Maximum number of Boards per VPI System	4	
Board slots required	1	
Maximum Board Logic Current Supply Draw	750 mA	
Supports 29040 Flash PROM	Yes	
No. of Sync./Async. Ports	2	1
No. of Async. only Ports	3	3
MAC interface	EIA232	EIA232
Network port/type	No	No
Daughterboard used	31166-187-01	31166-187-02
Additional Assembly Information		DC Code Line

6.2.1.2 Assemblies

Table 6–2. CSEX3 Board Assemblies

Description	Part Number
CSEX3, 2 EIA232/EIA422/EIA485, 3 EIA422, EIA232/EIA422/EIA485 MAC, blank FLASH PROMs, 36-pin Aux. Bd.	31166-175-02
CSEX3, 1 EIA232/EIA422/EIA485, 1 DC code I/F, 3 EIA422, EIA232/EIA422/EIA485 MAC, blank FLASH PROMs, 36-pin Aux. Bd.	31166-175-03

6.3 NON-VITAL INPUT BOARDS

6.3.1 NVI (Non-Vital Input) Board P/N 59473-757

The Non-Vital Input board provides 32 isolated, Non-Vital inputs interface through the motherboard to the VPI module. A CSEX board, employing Non-Vital I/O control software, communicates over the motherboard bus to the NVI board. Input states are latched and read every 25 ms by the NVP board.

6.3.1.1 Isolated Inputs

Optical isolators separate the power supplies of the 5V logic system and field circuitry. Each of the four groups of eight inputs has a separate signal return, allowing inputs derived from four isolated supplies to share one input board.

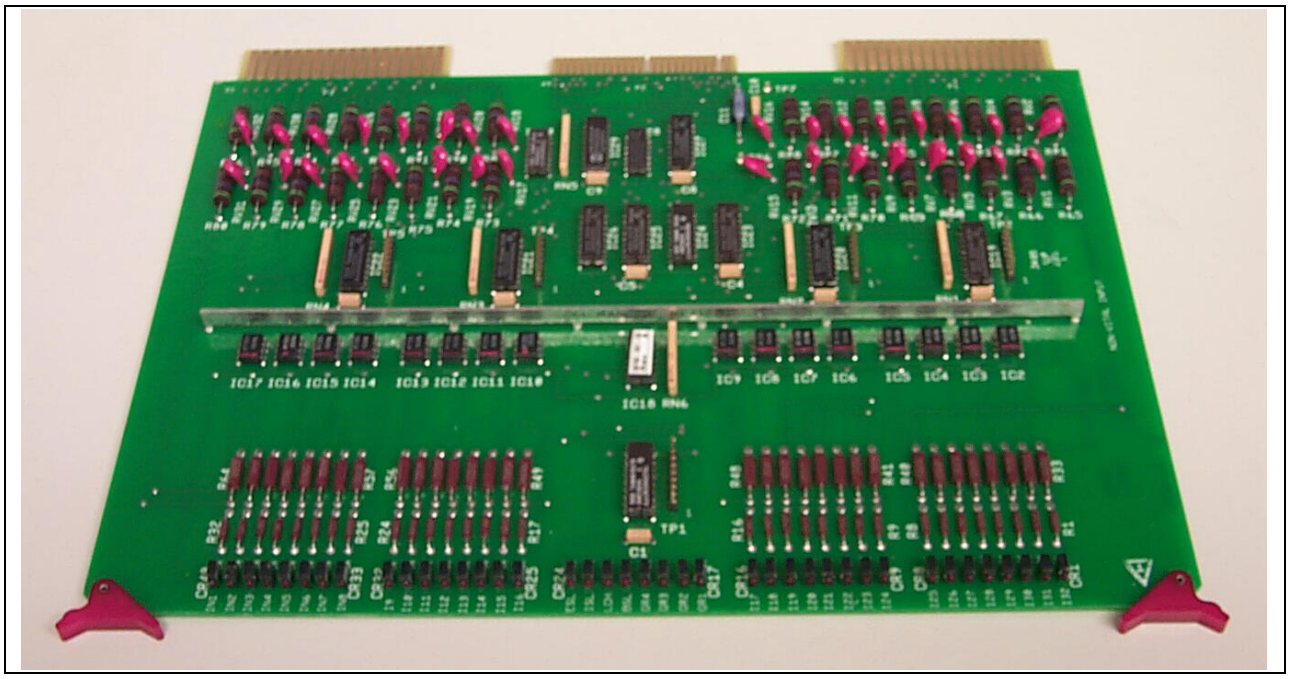


Figure 6-3. NVI Board

6.3.1.2 Specifications/Assembly Differences

Table 6–3. NVI Board Specifications

Characteristic	Specification	
	59473-757-	
	02	03
Maximum number of Boards per NVP Subsystem	20	
Board slots required	1	
Number of ports per board	32	
Maximum Board Logic Current Supply Draw	200 mA	
Minimum Input Voltage Per Port	18.0 VDC	9.0 VDC
Maximum Input Voltage Per Port	33.0 VDC	18.0 VDC
Minimum Activation Current Per Port	10 mA (Source)	7 mA (Source)

6.3.1.3 Assemblies

Table 6–4. NVI Board Assemblies

Description	Part Number
NVI, 32 inputs (18 – 33 VDC)	59473-757-02
NVI, 32 inputs (9 – 18 VDC)	59473-757-03

6.3.2 NVID (Non-Vital Input Differential) Board P/N 31166-106

The Non-Vital Input Differential board provides 32 isolated Non-Vital Inputs to a VPI system. Interface to the system is accomplished through the system motherboard. A Code System Emulator employing Non-Vital I/O control software communicates over the motherboard bus to the NVID board. Input states are latched and then read every 25 ms.

On-board jumpers permit configuration of the inputs as:

1. common cathode
2. common anode
3. isolated (i.e., differential)

6.3.2.1 Specifications

Table 6–5. NVID Board Specifications

Characteristics	**Specification**				
	31166-106-				
	01	**02**	**03**	**04**	**05**
Maximum number of Boards per CSEX Subsystem	20				
Board slots required	1				
Number of ports per board	32				
Maximum Board Logic Current Supply Draw	200 mA				
Minimum Input Voltage Per Port	4.5 VDC	18 VDC	9 VDC	9 VDC	18 VDC
Maximum Input Voltage Per Port	14.5 VDC	33 VDC	16 VDC	16 VDC	33 VDC
Nominal Wetting Current at Rated Input	5 ma	6 ma	3.6 ma	3.6 ma	6 ma
Input Sensitivity (min. input voltage to be read as “1”)	0.7	2	0.9	3	13

6.3.2.2 Assemblies

Table 6–6. NVID Board Assemblies

Description	Part Number
NVID, 32 six volt inputs	31166-106-01
NVID, 32 twenty-four volt inputs	31166-106-02
NVID, 32 twelve volt inputs	31166-106-03
NVID, 32 twelve volt inputs	31166-106-04
NVID, 32 twenty-four volt inputs	31166-106-05

6.3.3 NVIDSW (Non-Vital Input Differential Switch) Board P/N 31166-276

The Non-Vital Input Differential Switch Board provides 32 isolated non-Vital inputs to a VPI system. Interface to the system is accomplished through the system motherboard. Input states are latched, and then read, every 25 ms. Assembly 01 of the NVIDSW board provides the ability to physically set the state of the inputs through 32 switches located on the front of the board. Assembly 02 functions identically to the NVID board, and has no switches.

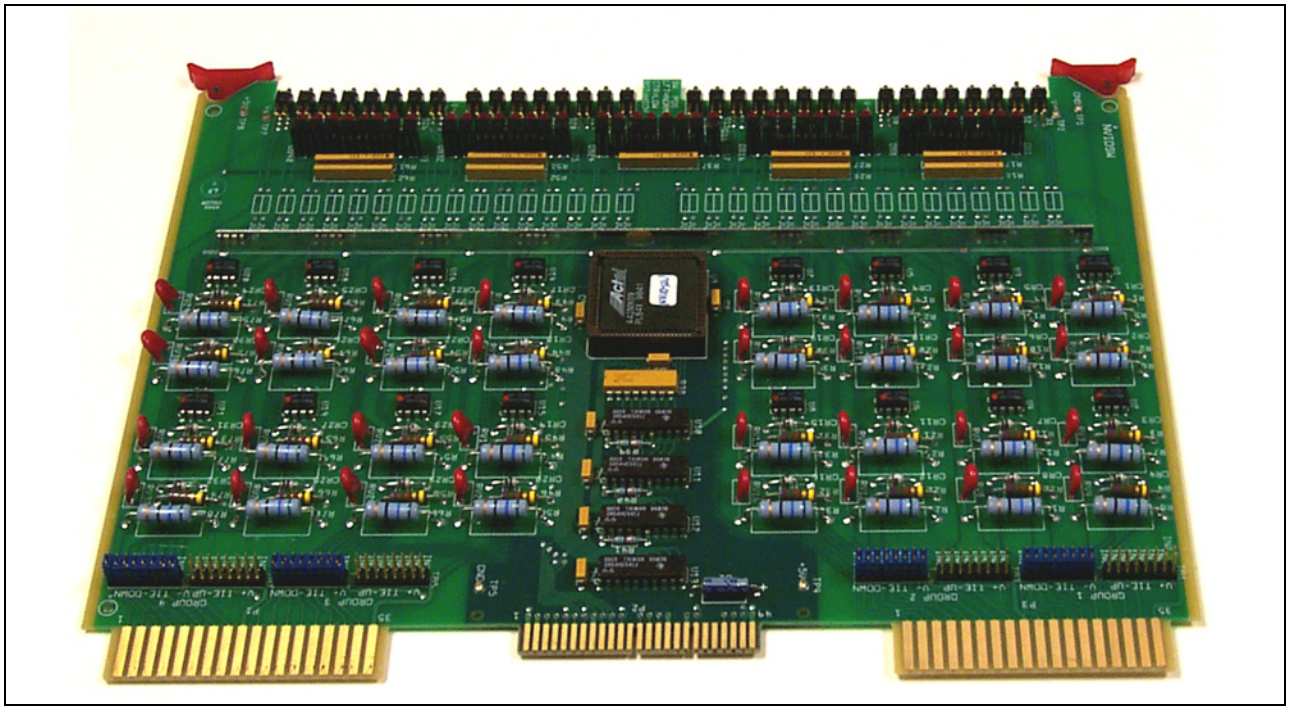


Figure 6-4. NVIDSW Board

6.3.3.1 Specifications

Table 6–7. NVIDSW Board Specifications

Characteristics	Specification			
	31166-276-			
	01	02	03	04
Maximum Number of Boards per NVP Subsystem	20			
Board Slots Required	1			
Number of Ports per Board	32			
Maximum Board Logic Current Supply Draw	200 mA			
Minimum Input Voltage Per Port	9V	9V	18V	18V
Maximum Input Voltage Per Port	18V	18V	33V	33V
Switches to force each input on/off	Yes	No	Yes	No

6.3.3.2 Assemblies

Table 6–8. NVIDSW Board Assemblies

Description	Part Number
NVIDSW, 32 inputs with “Force Input” switch	31166-276-01
NVIDSW, 32 inputs with “Force Input” switch	31166-276-02
NVIDSW, 32 inputs with “Force Input” switch	31166-276-03
NVIDSW, 32 inputs with “Force Input” switch	31166-276-04

6.4 NON-VITAL OUTPUT BOARDS

Non-vital output boards are available with DC solid-state outputs in sinking and sourcing configurations. Also, solid-state AC versions and Form A relay contact versions are available.

6.4.1 NVO (Non-Vital Output) Boards P/N 59473-785 and 59473-936

The Non-Vital Output (NVO) board (59473-785) and Non-Vital Output AC (NVOAC) board (59473-936) provide 32 isolated non-Vital outputs. An NVP board, employing non-Vital I/O control software, communicates over the motherboard bus via the P2 connector to the NVO board.

6.4.1.1 Isolated Outputs

Optical isolators separate the power supplies of the 5V logic system and field circuitry. Each of the four groups of eight outputs possesses a separate power feed and signal return, allowing interface with four distinctly different supplies.

Various board assemblies have different output voltage ratings (see specifications). Outputs can source up to 250 mA.

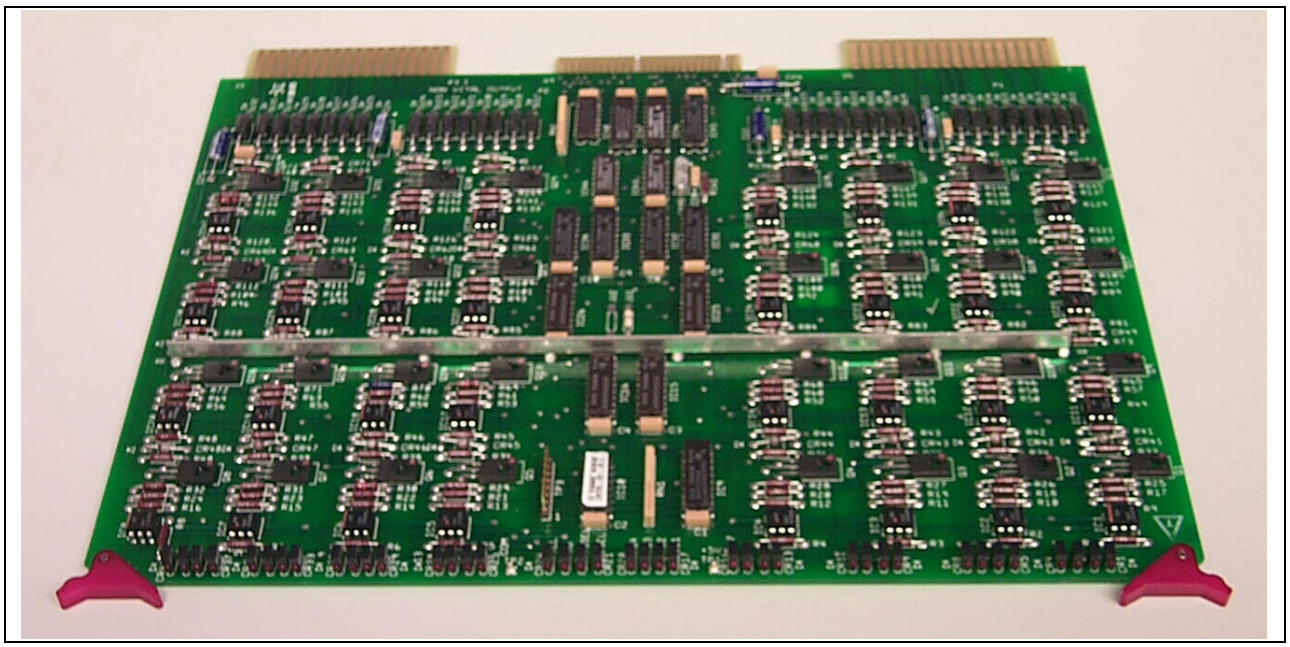


Figure 6-5. NVO Board

6.4.1.2 Specifications/Assembly Differences

Table 6–9. NVO Board Specifications/Assemblies

Characteristic	Specification		
	59473-785-		
	03	04	05
Maximum number of Boards per NVP Subsystem	20		
Board slots required	1		
Number of ports per Board	32		
Maximum Board logic Current Supply Draw	500 mA		
Minimum Switched Output Supply Voltage	18.0 VDC	9.0 VDC	4.5 VDC
Maximum Switched Output Supply Voltage	33.0 VDC	18.0 VDC	14.5 VDC
Maximum Output Current per Port (Source)	0.25 A		
Power On Reset (POR)	Yes		

Table 6–10. NVOAC Board Specifications

Characteristic	59473-936-02
Maximum number of Boards per CSEX Subsystem	20
Board slots required	1
Number of ports per Board	32
Minimum Switched Output Supply Voltage	5.0 VAC
Maximum Switched Output Supply Voltage	250 VAC
Maximum Output Current per Port	0.25 A
Frequency Range	47 - 70 Hz
Power On Reset (POR)	Yes

6.4.1.3 Assemblies

Table 6–11. NVOAC Board Assemblies

Description	Part Number
NVO, Sourcing 18 – 33 VDC, with POR	59473-785-03
NVO, Sourcing 9 – 18 VDC, with POR	59473-785-04
NVO, Sourcing 4.5 – 14.5 VDC, with POR	59473-785-05
NVOAC, 5 – 250 VAC, with POR	59473-936-02

6.4.2 NVO-SNK (Non-Vital Output Sink) Board P/N 31166-123

The Non-Vital Sink Output board provides a VPI system with 32 Non-Vital, latched, isolated, open drain, current sinking outputs, each capable of driving TTL or CMOS logic inputs. (Note: logic inputs must be provided with an appropriate pull-up resistor.) The outputs are divided into four groups of eight. The outputs are controlled, via the system bus on the system motherboard, by a Code System Emulator board (CSEX), running Non-Vital I/O control software.

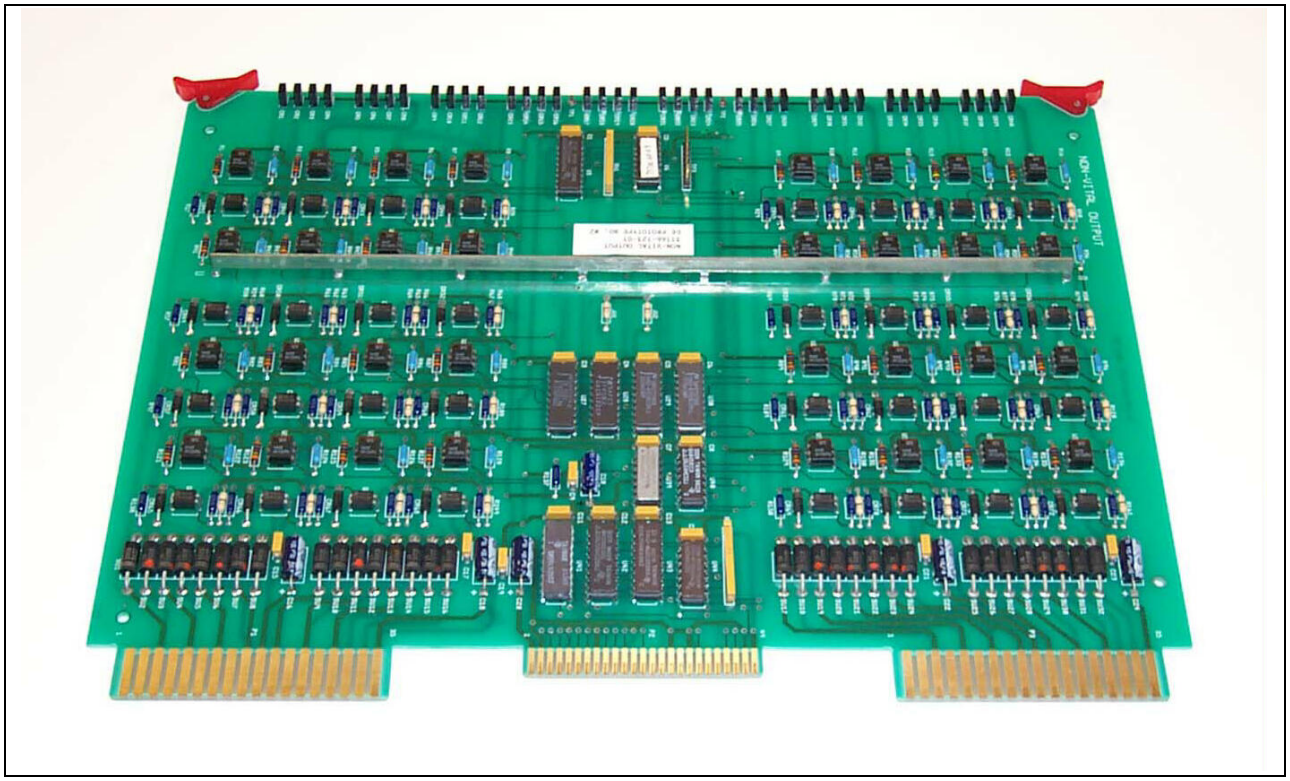


Figure 6-6. NVO-SNK Board

6.4.2.1 Specifications

Table 6–12. NVO-SNK Board Specifications

Characteristic	31166-123-01
Maximum number of Boards per CSEX Subsystem	20
Board slots required	1
Number of ports per Board	32
Minimum Switched Output Supply Voltage	4.5 VDC
Maximum Switched Output Supply Voltage	14.5 VDC
Maximum Output Current per Port	0.25 A (sink)
Power On Reset (POR)	Yes

6.4.2.2 Assembly

Table 6–13. NVO-SNK Board Assembly

Description	Part Number
NVO-SNK, 32 sinking 4.5 – 14.5 VDC	31166-123-01

6.4.3 NVR (Non-Vital Relay Output) Board P/N 31166-238

The Non-Vital Relay Output (NVR) board (31166-238) provides 32 Form A non-vital relays interfaced through the system backplane to the connectors on the back of the module. A NVP board, employing non-vital I/O control software, communicates over the motherboard bus via the P2 connector to the NVR board. Internal circuitry on the NVR board disables outputs at power-up until a NVP board writes to this board to initialize the outputs.

The NVR board is functionally equivalent to its NVO (non-vital output) predecessors, except for power requirements, and the existence of the FPGA. The outputs are grouped in four groups with eight outputs each, as they are in the NVO board, but the outputs on the P1 and P3 connectors are assigned two pins each, an even and an odd. If the output is currently active, these two pins will be connected through the associated relay, allowing current flow.

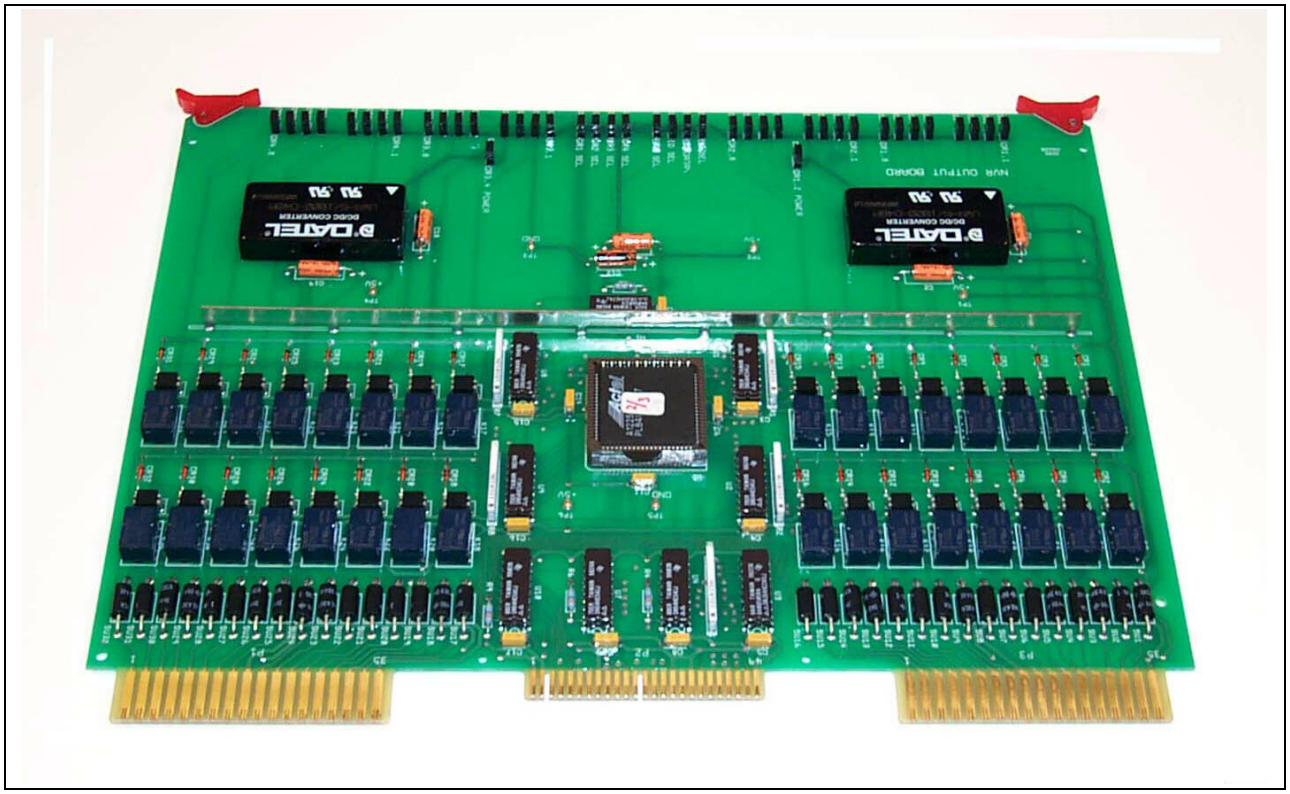


Figure 6-7. NVR Board

6.4.3.1 Specifications

Table 6–14. NVR Board Specifications

Characteristic	Specification	
	31166-238-	
	01	02
Maximum Number of Boards per CSEX Subsystem	20	
Board Slots Required	1	
Number of Ports per Board	32	
Maximum Board Logic Current Supply Draw	500 mA	
Minimum Switched Coil Energy Supply Voltage	9.0 VDC	18.0 VDC
Maximum Switched Coil Energy Supply Voltage	18.0 VDC	35.0 VDC
Maximum Current per Relay Contact Port	1 A	
Maximum Contact Power Rating	30 W / 62.5 VA	
Maximum Contact Voltage	34.8 VDC[3]	34.8 VDC
Power On Reset	Yes	

6.4.3.2 Assemblies

Table 6–15. NVR Board Assemblies

Description	Part Number
NVR, 32 Form A, 9 – 18 V coil supply	31166-238-01
NVR, 32 Form A, 18 – 35 V coil supply	31166-238-02

3 This is a limit imposed by the 1.5KE43CA bi-directional suppressor. Actual contact rating is 100 VDC or 125 VAC

6.5 TRAIN TO WAYSIDE COMMUNICATIONS BOARDS

The Non-Vital Train-to-Wayside Communications Modem board is the wayside part of the Train to Wayside Communications (TWC) system. TWC is a two-way communication link consisting of a transmitter/receiver set (transceiver) aboard the train and a similar set in wayside systems. The system provides communication between the car-carried equipment and the wayside equipment for the transfer of routing, dispatch information and for monitoring by central control. This board demodulates analog frequency information into a digital form and passes it on to a NVP board. It also takes digital information from the NVP board and converts it to analog frequency form to be transmitted to the train.

As with the CSEX board series, the TWC board series has evolved over the years of application to reach higher levels of integration and functionality. The present board assemblies supporting the TWC function are the 31166-119 series.

6.5.1 NVTWC-FSK (Non-Vital TWC FSK) Board P/N 31166-119

The Non-Vital TWC FSK board provides true Frequency Shift Keying TWC. The incoming TWC messages are keyed such that the logic 1 and logic 0 frequencies are based symmetrically around some base frequency (example: 9650 ± 150 Hz). This board uses 4 Phase Lock Loops (1 per channel) to decode the incoming signals. The output of the phase lock loops are then reformatted so that they can then be sent to the CSEX board. Firmware on board validates the received message before it is sent to the NVP to reduce or eliminate the effects of noise-induced errors.

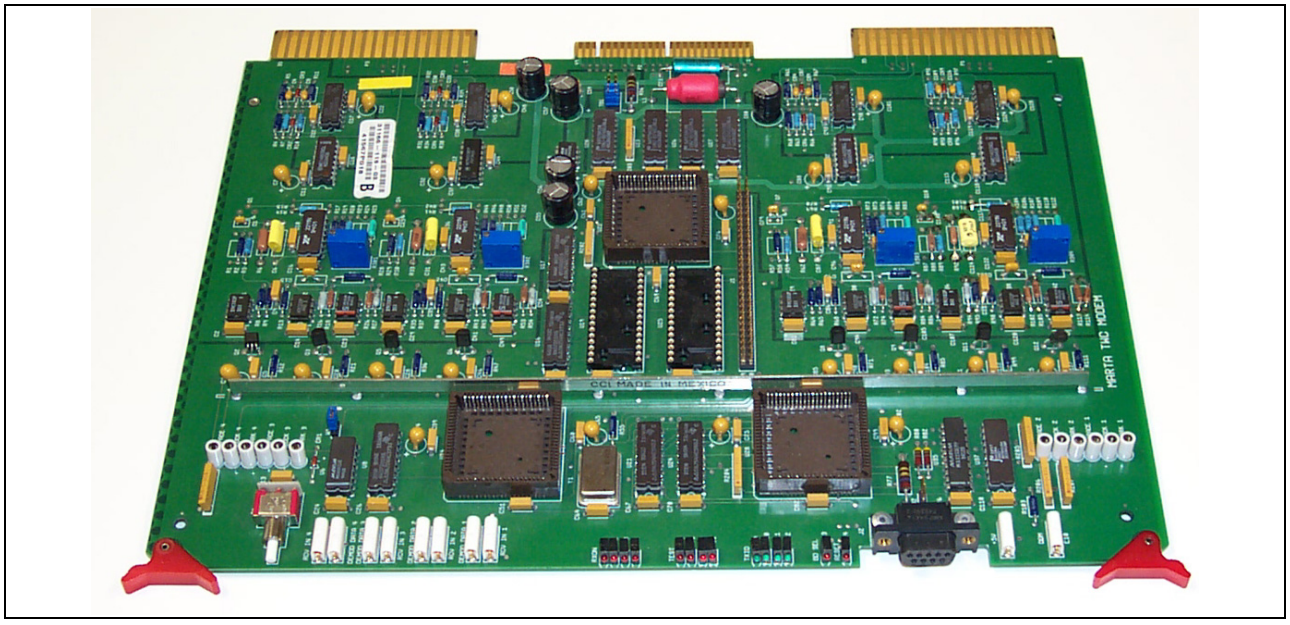


Figure 6-8. NVTWC-FSK Board

6.5.1.1 Specifications

Table 6–16. NVTWC-FSK Board Specifications

Characteristic	Specification				
	31166-119-				
	02	03	04	05	06
Maximum number of Boards per NVP Subsystem	8				
Board slots required	1				
Maximum Board Logic Current Supply Draw	350 mA				
Number of detection channels	4				
Maximum Baud Rate	110	110	100	4800	100
Maximum detection frequency	10 kHz	10 kHz	10 kHz	70 kHz	10 kHz
Software	4 Ch. Rec. only (40025-238)	4 Ch. T/R (40025-242)	4 Ch. T/R (40025-284)	4 Ch. T/R (40025-289)	4 Ch. T/R (40025-295)

6.5.1.2 Assemblies

Table 6–17. NVTWC-FSK Board Assemblies

Description	Part Number
NVTWC-FSK 4 Channel TWC Receive only (40025-238-00 Software) for MARTA	31166-119-02
NVTWC-FSK 4 Channel TWC Transmit/ Receive (40025-242-00 Software) for Shanghai, Taipei, Taegu	31166-119-03
NVTWC-FSK 4 Channel TWC Transmit/ Receive (40025-284-00 Software) for WMATA	31166-119-04
NVTWC-FSK 4 Channel TWC Transmit/ Receive (40025-289-00 Software) for Seoul Metro Line 6	31166-119-05
NVTWC-FSK 4 Channel TWC Transmit/ Receive (40025-295-00 Software) for WMATA test fixture	31166-119-06

SECTION 7 – VPI DESIGN, TEST AND VALIDATION TOOLS

7.1 GENERAL

In support of design, verify test, install and maintenance aspects of a typical interlocking project, the industry's most comprehensive suite of tools are provided for use with VPI.

- **Design Framework** – **Computer Aided Application Programming Environment** [**CAAPE**] - Graphical design and simulate. Provides for graphical hardware configuration, relay or ladder logic program definition and communication assignments
- **Design Verifier** - **Application Data Verifier** [**ADV**] - Inverse compiler that generates reports from application files illustrating hardware configurations and interlocking logic design as resident within EPROM to be installed in VPI field equipment. Produces documentation following changes to reduce retest of interlocking following changes to interlocking logic or configuration.
- **Monitor Realtime VPI Operation** - **Watcher** - Views application variables' real-time status during factory, field or post installation. Reduces test time and facilitates field troubleshooting.
- **Operational Records** – **Embedded Datalogger** - View on-board event records for all application parameters. Time stamped and interactive display of logged data.
- **Remote Collection of Event and Diagnostic Records** – **Tracker** – Remote access to VPI System diagnostics and event records, Tracker identifies a root cause failure to a primary VPI failure with suggested responses for field personnel. Also used as a remote collection mechanism for system event records.
- **Circuit Check and Factory/Field Test Support** - **TestWrite** – Generates test sheets based on graphical track layouts. Serves as an independent validation of interlocking functional design for VPI or relay based interlockings.
- **One Stop VPI Control, Monitoring, Diagnosis and Maintenance Planning - Maintenance Mgmt System [MMS] –** A PC based user friendly interactive program installed within an interlocking rack of equipment. Integrates Watcher, Tracker, Tests Write, etc. VPI support tools from above for use with Field Install and Test, Maintenance and Preventive Maintenance and Condition Monitoring of field devices.

7.2 CAAPE- AN INTEGRATED WINDOWS-BASED CONFIGURATION TOOL

The Computer-Aided Application Programming Environment (CAAPE) is a comprehensive set of development tools for creating VPI Vital and non-vital applications. These tools are integrated together within a development environment for easy access. It is intended for use by Alstom signal engineers, third party signaling consultants, and railroad and transit signal engineers.

CAAPE, for use with Windows XP (SP3), Windows 7 32-bit and Windows 7 64-bit operating systems (Windows 7 operating systems are supported in CAAPE 019B and later), includes the following:

- Compilers for VPI Vital and non-vital application
- Application Data Verifier (ADV) for VPI
- Simulators for VPI Vital and non-vital logic
- Genrakode II Control Point in a Box applications for downloading to Genrakode II coded track circuit
- Utilities such as:
  - PROM file generation
  - Label generation for HP and Intergraph plotters
  - Consolidation report for VPI ADV
  - Genrakode II download
  - Relay equivalent circuits for final documentation
  - Genrakode II compiler and ADV may optionally be added

The CAAPE package uses a project-based architecture that allows the user to create projects containing any number of VPI applications. Computer programming experience is not required; applications can be built using either graphical or textual methods. The graphical methods include form entry, pull-down lists, extensive prompts, online documentation, and a HELP facility to guide the designer through the process. An extensive, stand-alone tutorial is also provided for easy training and reference.

The CAAPE package can be used for both Vital and non-vital applications, and includes a database function to store and organize all relevant data. An extensive documentation section makes it easy to track applications through various stages of development and provides enhanced revision control.

Online, context-sensitive assistance is available through the HELP facility in the form of a SEARCH window. Also accessible from the HELP menu, the comprehensive tutorial provides an easy reference guide and training tool for the CAAPE package. The program allows the viewer to follow the creation of a typical new application from the beginning to end, and also contains an index for handy access to the main control topics.

7.2.1 CAAPE

The CAAPE design tool shows project contents, graphical logic editing and compile results in message window to illustrate the integrated nature of CAAPE.

- Integrated project-oriented environment for developing, compiling, and verifying applications and for managing input, output and report files.
- Graphical entry of application data, including graphical logic with straight or drop line symbols; traditional text-based application data entry is still supported as well.
- Compiler configuration reports include date/time of input and output files, system software versions, calculated checksums and CRCs.

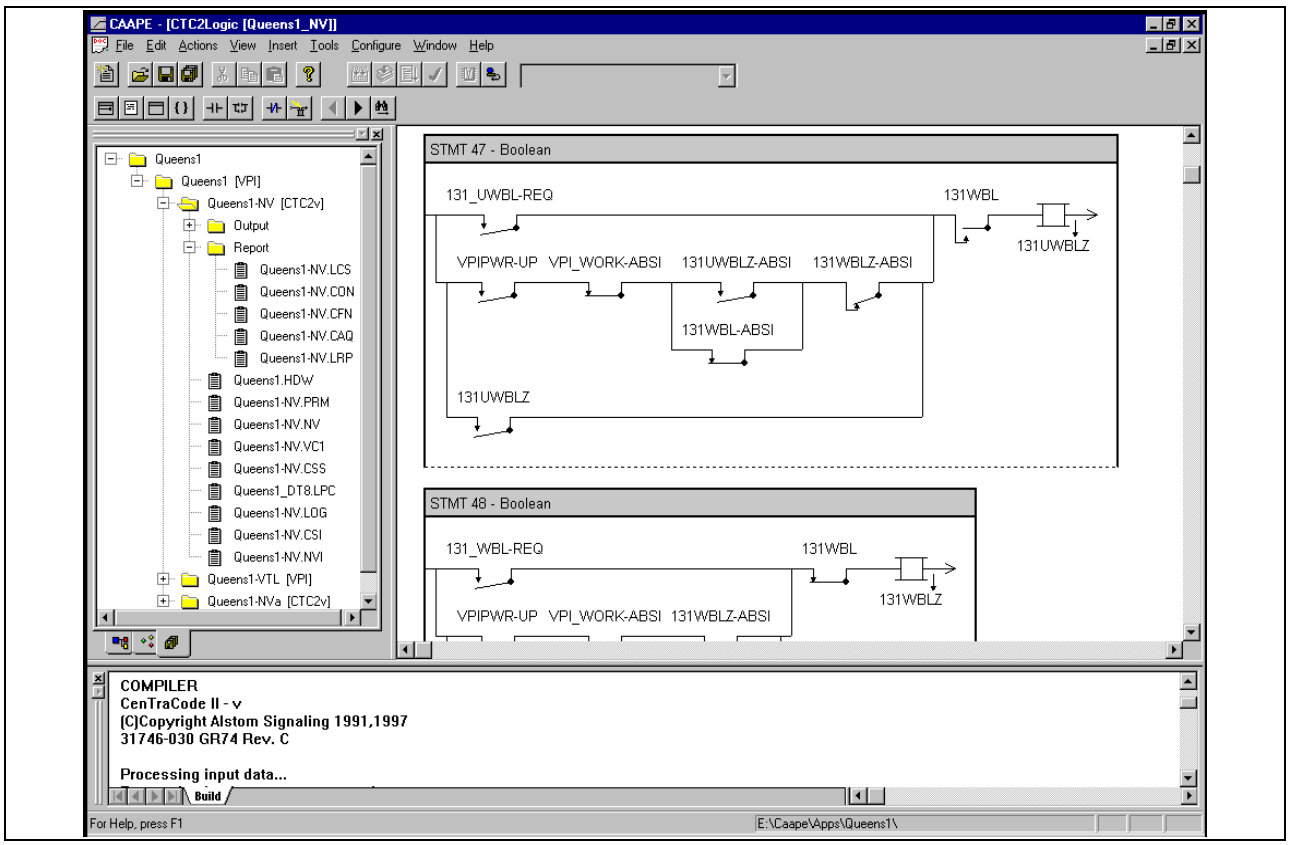


Figure 7-1. CAAPE Non-Vital Relay Application Logic Display

7.2.2 Application Verification

Critical CAAPE utility that is used to both verify compiled design as it is resident in System Memory and highlight differences between complies. The latter is extremely important where multi-phase projects require many incremental changes without having to retest entire interlocking plant. In general, the ADV:

- Reconstructs Application Design From EPROM
- Generates Reports For Circuit Check
- Creates the Equivalent of an Electronic Book Of Plans
- Provides for a Difference Utility Highlights Changes
- Provides Security Far Beyond Checksums
- Validates Configuration Management

Specifically:

- Application Data Verifier (ADV) helps verify that application prom data matches intended user input. New Consolidation Reports simplify analysis of ADV data.
- “Graphical ADV” helps verify that graphically entered logic matches prom data. This is a specialized aspect of the ADV for users who enter logic graphically. There is no graphical verification report.
- ADV Compare program compares ADV reports to highlight differences between applications in their Vital logic, symbols, messages and I/O.

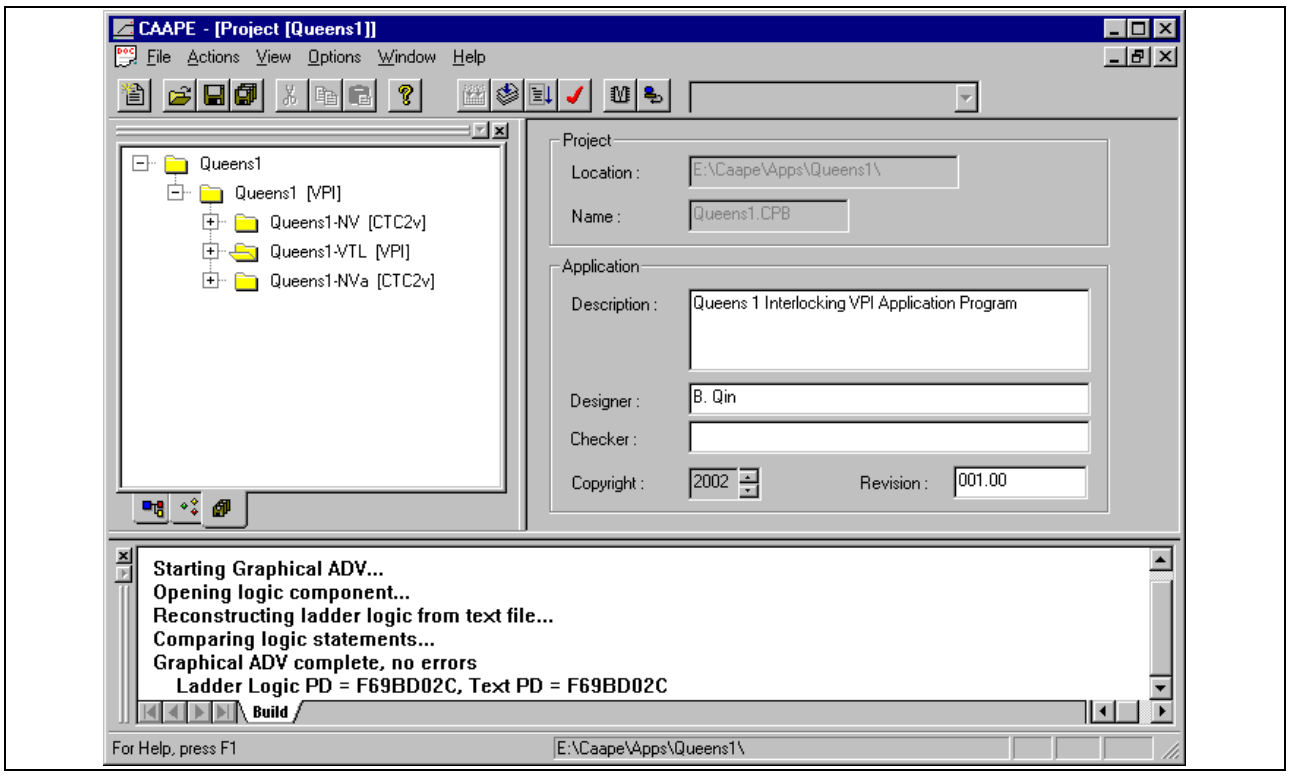


Figure 7-2. Graphical ADV - Compares Logic Input to Output Files w/CRCs

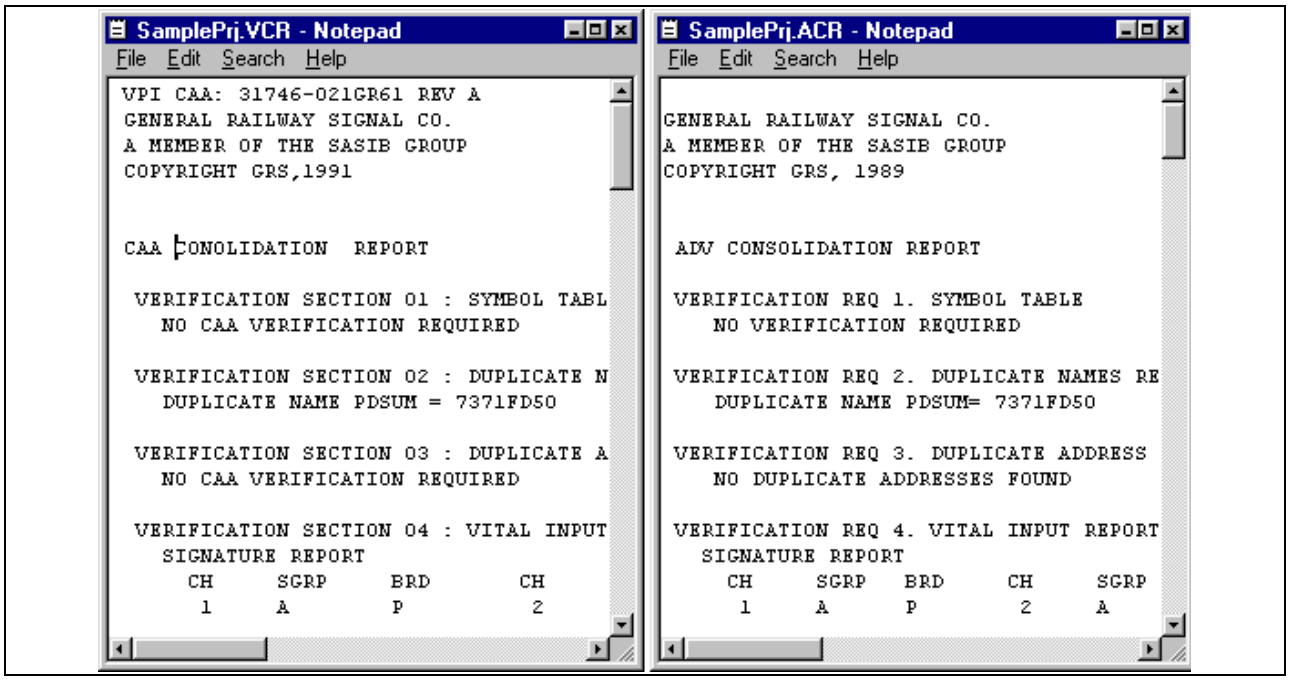

SamplePrj.VCR - Notepad
File Edit Search Help
VPI CAA: 31746-021GR61 REV A
GENERAL RAILWAY SIGNAL CO.
A MEMBER OF THE SASIB GROUP
COPYRIGHT GRS,1991
CAA CONOLIDATION REPORT
VERIFICATION SECTION 01 : SYMBOL TABL
NO CAA VERIFICATION REQUIRED
VERIFICATION SECTION 02 : DUPLICATE N
DUPLICATE NAME PDSUM = 7371FD50
VERIFICATION SECTION 03 : DUPLICATE A
NO CAA VERIFICATION REQUIRED
VERIFICATION SECTION 04 : VITAL INPUT
SIGNATURE REPORT
CH SGRP BRD CH
1 A P 2
SamplePrj.ACR - Notepad
File Edit Search Help
GENERAL RAILWAY SIGNAL CO.
A MEMBER OF THE SASIB GROUP
COPYRIGHT GRS, 1989
ADV CONSOLIDATION REPORT
VERIFICATION REQ 1. SYMBOL TABLE
NO VERIFICATION REQUIRED
VERIFICATION REQ 2. DUPLICATE NAMES RE
DUPLICATE NAME PDSUM= 7371FD50
VERIFICATION REQ 3. DUPLICATE ADDRESS
NO DUPLICATE ADDRESSES FOUND
VERIFICATION REQ 4. VITAL INPUT REPORT
SIGNATURE REPORT
CH SGRP BRD CH SGRP
1 A P 2 A

Figure 7-3. ADV Compare Application Utility

7.2.3 CAAPE System Requirements

Table 7–1 shows the computer and operating system requirements for CAAPE.

Table 7–1. Computer and Minimum Operating System Requirements

Description	Requirement
Operating System	Windows® XP SP3, Windows 7 32-bit and Windows 7 64-bit (Windows 7 operating systems are supported in CAAPE 019B and later)
RAM	64 MB
CPU	Pentium or compatible
Hard Disk	400 MB available
Input Device	Keyboard and mouse
Display	SVGA (800 x 600)
Ports	Serial Port | COM port or USB

7.3 WATCHER

Watcher is a PC based tool that operates with embedded VPI software to provide real time review of internal execution of the interlocking thorough a connection to the non-vital system controller. Its prime task is to:

- Monitor and record the real-time states of selected Vital or non-vital variables.
- View application logic equations in graphical or text format, including the real-time states of their variables.
- View detailed diagnostic screens in VT100 format.

Note: Watcher is not certified to run on Windows 7 platform

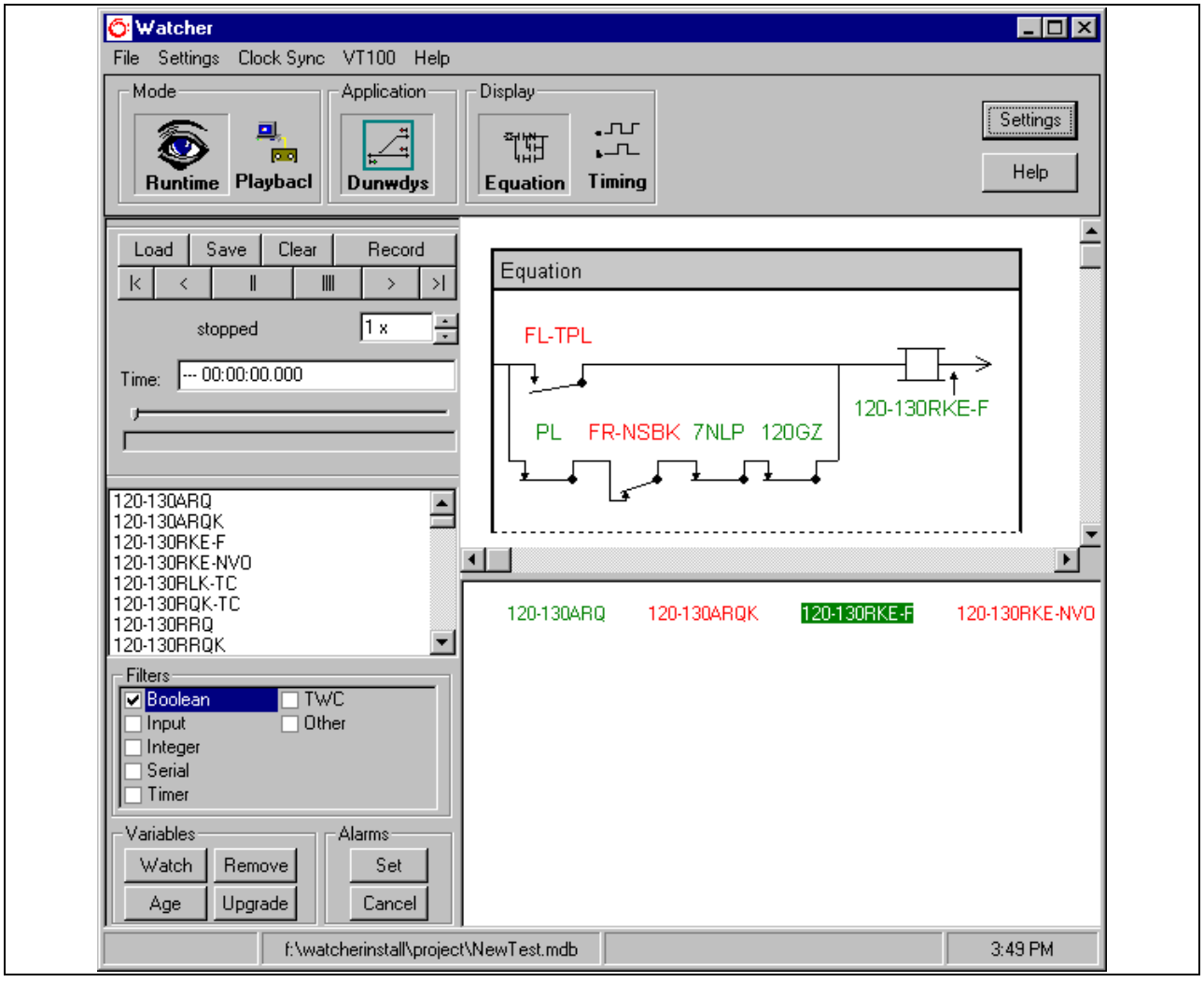


Figure 7-4. Watcher Main Screen – View Logic and State

7.4 EMBEDDED DATALOGGER

A feature provided by the non-vital subsystem, the embedded data logger permits viewing of timestamped events in log form or in near real-time chart recorder form. Multiple views are provided.

Key features are:

- View Events Historical, Real Time
- Filters Unwanted Info
- Saves Data In Nonvolatile Memory
- Timeline and Timestamp Views
- Record time-stamped events to on-board battery-backed memory.
- Event capacity is typically several days.
- Automatically detect a change to a large number of user-specified application parameters, and record when changes occur in real-time.
- On-line help is available to assist the operator.

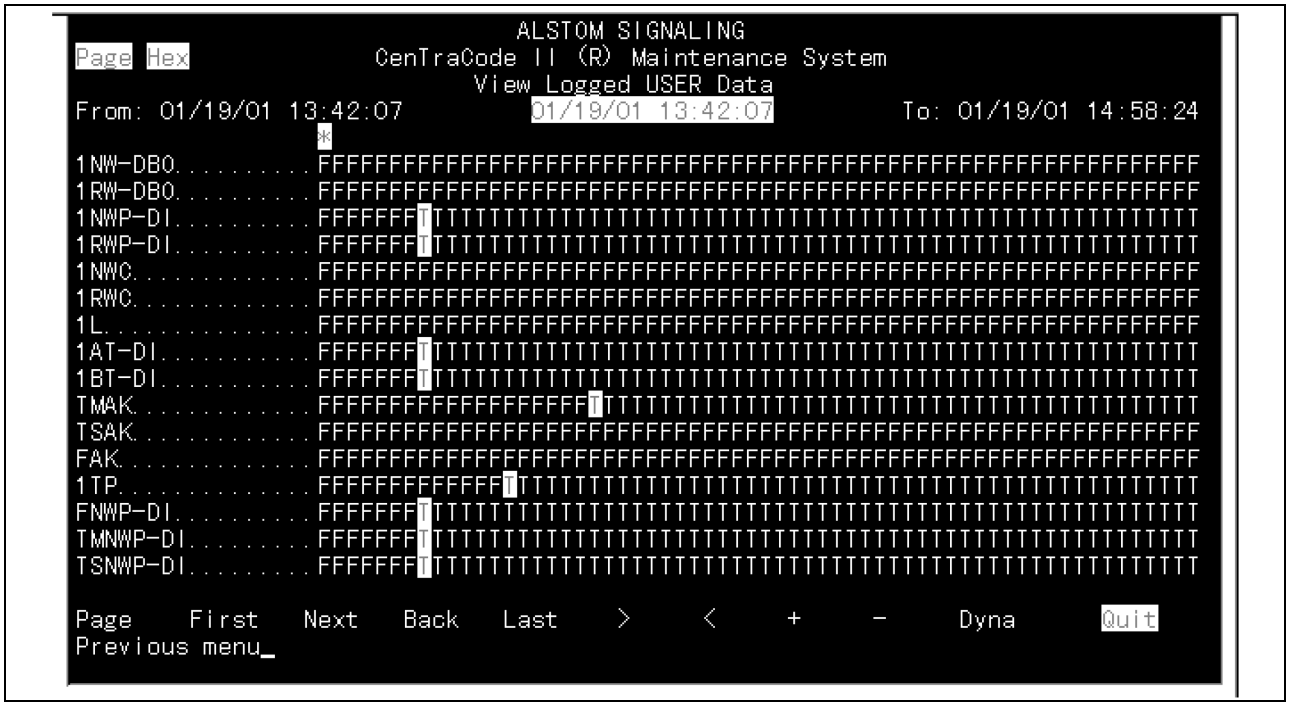


Figure 7-5. Screen View of User Data

7.5 TRACKER REMOTE DIAGNOSTIC ANALYZER

Tracker is a software package with a number of features intended to make problem detection and diagnosis easier for the user. A PC based Windows product, Tracker is used to automatically identify VPI system failures and produce alarms at a central site. Tracker also serves as a centralized server for the collection of VPI Datalogger event records from field sites. Basic features are fault detection, logging, data retrieval and report creation.

Note: Tracker is not certified to run on Windows 7 platform

7.5.1 Fault Detection

In the convenience of an office setting, the Tracker Diagnostic Analyzer Software can provide full-time and part-time monitoring of multiple field device sites simultaneously, and can be configured to sound an alarm when a malfunction occurs. When a fault is detected, the Tracker software can be configured to diagnose the problem to indicate the fault or field condition. This helps ensure that proper spares are taken to the site the first time, thus minimizing system down time.

7.5.2 Logging

The Tracker software provides an historical log of errors detected so that the events leading up to a particular failure can be later analyzed for possible trends. Based on analysis of the log, preventive action may be possible to protect against future problems.

7.5.3 Data Retrieval and Report Creation

Tracker can retrieve historical event data from field devices for archival and analysis. Reports are available.

7.6 TESTWRITE

TestWrite is a software package generally used by a quality assurance engineer or circuit check design personnel to separately validate that the logic being implemented by the interlocking logic design engineer meets the safety critical needs of the railroad. The user easily generates a track layout from a set of graphical tools. TestWrite can then automatically determine all routes in the system. The user then builds test steps for each route, by assigning states (inputs/outputs) to each graphical element. Steps can be grouped to form individual test scenarios. TestWrite then develops a test description document for the assigned test scripts. The final document is available in Word or text format.

For interlocking configurations, the tool is used to create a set of rules that reveal how the interlocking functions, route, time, indication, locking are to operate and be tested; independent of the actual signal design executable. Sample output for the *TestWrite* tool are included below. The features this tool provides are indicated here:

- Quick Track Layout Builder – simple graphical tool to draw track layout. Symbols for tracks, switch machines, signals, etc. are available. This graphical view of the interlocking is later used by the VPI MMS as an active display to provide actual local control panel displays or used as the visual display of test results.
- Route Wizard – Analyzes the final track layout and generates a listing of routes through the interlocking. This list along with the physical elements assigned form the foundation for defining test strategies.
- Test scenario reports – for each route, a test scenario is defined that provides a sequence of test to be performed. When test scenarios are initiated through the VPI MMS, the test scenarios are provided to a graphical display for assisting the test engineer through the test.

TestWrite has four intended uses:

- Circuit check of electronic or relay based interlocking logic
- Generation of test sheets for reducing factory and field test time
- Secondary use for training signaling employees on interlocking rules specific to the operating authority and, in the future
- Framework to be used for performing automatic interlocking tests mandated by FRA or other regulatory bodies

The benefits are:

- Consistent rules for design
- Standardization of test sheet generation
- Electronic reports of actual factory or field test sequences executed by test engineer

Following are samples of TestWrite Screen and reports.

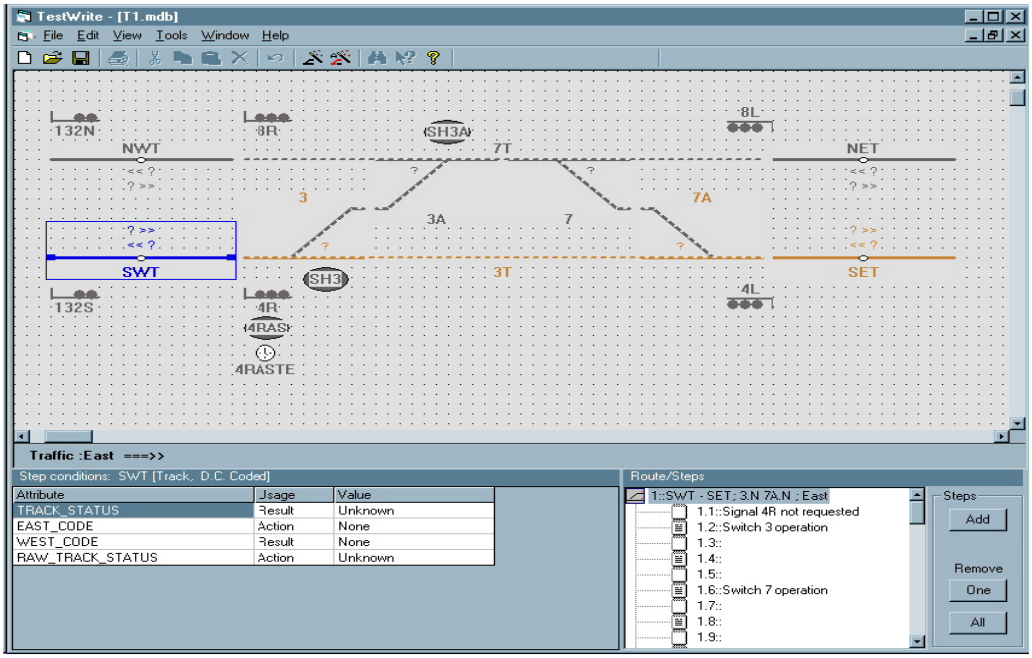


Figure 7-6. TestWrite User View

Route 1: SWT - SET; 3.N 7A.N ; East		
Steps	**Actions**	**Expected Results**
1.1: Signal 4R not requested		
1.2: Prove Switch 3 operation		
Reverse		
Shop ____ Field ____	Call switch 3 reverse	Switch 3 normal position input removed Switch 3 controlled reverse Switch 3A normal position input removed Switch 3A controlled reverse
1.3		
Shop ____ Field ____		Switch 3 in reverse position Switch 3 reverse control removed Switch 3A in reverse position Switch 3A reverse control removed
1.4		
Normal		
Shop ____ Field ____	Call switch 3 normal	Switch 3 reverse position input removed Switch 3 controlled normal Switch 3A reverse position input removed Switch 3A controlled normal

Figure 7-7. TestWrite Report

7.7 MAINTENANCE MANAGEMENT SYSTEM

The Maintenance Management System (MMS) is an Alstom diagnostic tool that can remotely monitor each VPI Vital and non-vital networked system.

MMS is a graphical diagnostic and maintenance application that uses a graphical track layout to dynamically record and display the VPI diagnostic status, the status of linked VPI variables and play back recorded data.

Additional tools are available to manage diagnostics, configuration, event and data logs, schedule maintenance tasks, and view, record and play back VPI application variable data.

For more information on this Alstom tool, refer to Alstom publication *P2509 Maintenance Management System for Alstom Vital Processor Interlocking Systems (VPI, VPI II, iVPI).*

SECTION 8 – NON-VITAL SYSTEM AND COMMUNICATIONS SOFTWARE

8.1 SYSTEM SOFTWARE INTERFACE MATRIX

The non-vital subsystem can simultaneously support multiple communication/code system protocols while performing non-vital input/output operations, application logic functions, train to wayside and wayside to train communications and data logging within the VPI system. The data logged information is time-stamped and can be viewed real-time, can be selected by the user by run-time or downloaded for off-line examination. The logic may be written using a combination of Boolean and higher-level programming techniques to control the communications and input/output functions.

WARNING

NON-VITAL SUBSYSTEM IS NOT FAIL-SAFE

The non-vital subsystem and communications software used in the VPI system is not designed for fail-safe application and must not be used for safety-critical operations.

Failure to comply can degrade the safety performance of the train control system resulting in property damage, injury, and/or death due to train collision or derailment.

8.2 APPLICATION

8.2.1 I/O

Non-vital inputs and outputs can interface to external equipment in order to provide indications to a remote office or to an adjacent location. Outputs are capable of flashing at 60 cycles per second or 120 cycles per second. Examples of inputs and outputs include the following:

- Local Control Panel
  - Switch Machine Normal and Reverse Request Controls
  - Switch Machine Normal and Reverse Position and Lock Indications
  - Signal Request, Fleet and Cancel Controls
  - Signal Aspect and Fleeting Indications
  - Traffic Indications
  - Snowmelter Controls and Indications
- Maintainer Calls
- Battery Power Alarms
- Ground Detection
- Fire Alarm
- Intrusion Alarm
- Room Temperature Monitor
- Track Indications
- System Health
- Redundancy Transfer

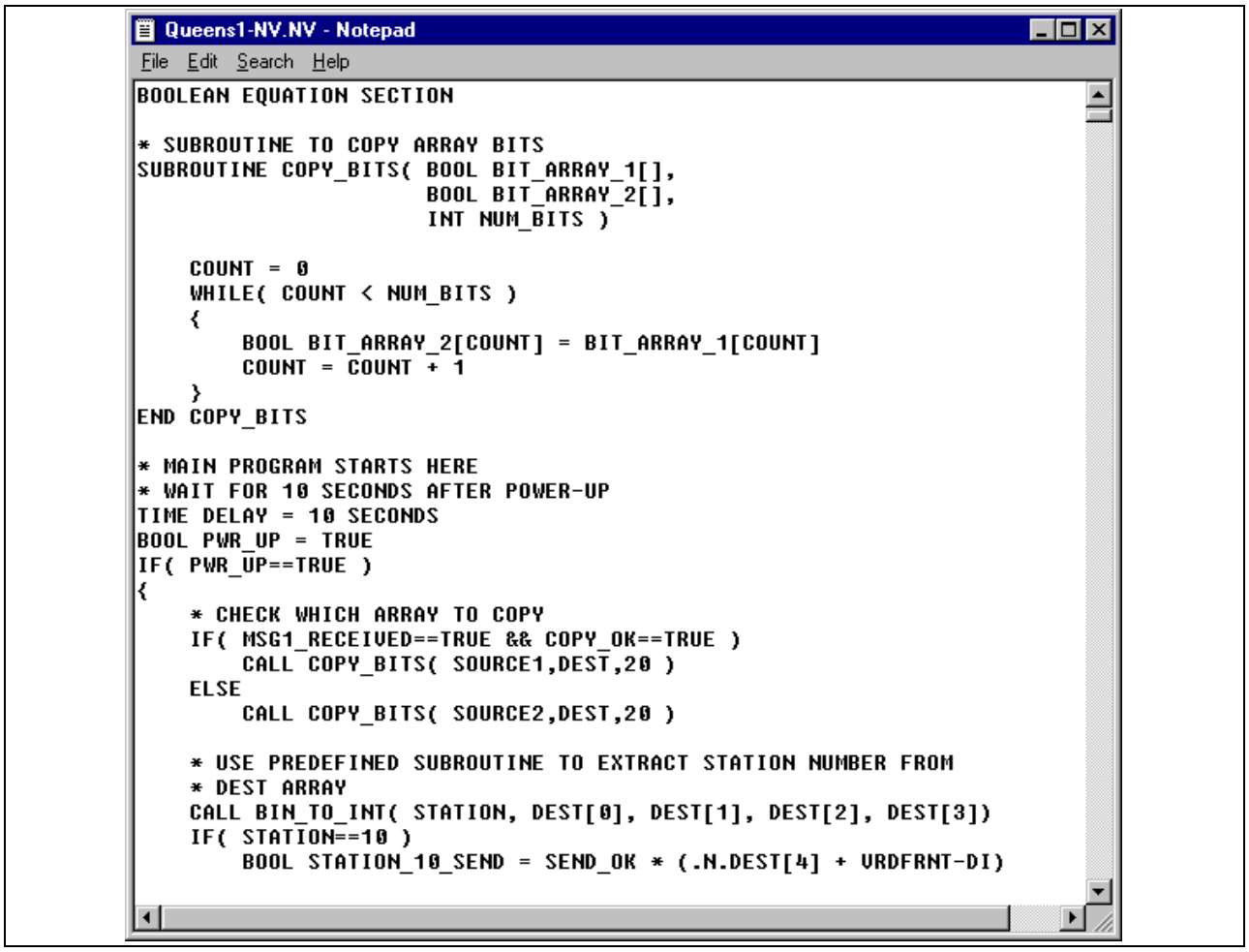
8.2.2 Logic

The non-vital logic can be written to perform a wide array of functions, including the following:

- N/X (Entrance/Exit) Interlocking Control
  - Controls provided from a local panel and/or a remote office
- Unilever Interlocking Control
- Remote Office Controls And Indications
- Train-to-Wayside and Wayside-to-Train Communications
  - Train Dwell Control
  - Train Identification
  - Train Berthing
- Automatic Train Operation
- Automatic Route Generation
- Auxiliary Train Tracking
- Interface to Vital Logic

8.2.2.1 Logic Statement Types

- Boolean Equations
- Timer Equations - delays the setting of an equation
- Integer Equations - arithmetic using variables and constants
- Program Flow Control: IF/ELSE, WHILE, GOTO
- User-Defined Subroutines: SUBROUTINE, CALL
- Predefined Subroutines: timer control, format conversion (e.g. Integer-Binary)
- Arrays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BOOLEAN EQUATION SECTION
* SUBROUTINE TO COPY ARRAY BITS
SUBROUTINE COPY_BITS(BOOL BIT_ARRAY_1[],
BOOL BIT_ARRAY_2[],
INT NUM_BITS)
COUNT = 0
WHILE(COUNT < NUM_BITS)
{
BOOL BIT_ARRAY_2[COUNT] = BIT_ARRAY_1[COUNT]
COUNT = COUNT + 1
}
END COPY_BITS
* MAIN PROGRAM STARTS HERE
* WAIT FOR 10 SECONDS AFTER POWER-UP
TIME DELAY = 10 SECONDS
BOOL PWR_UP = TRUE
IF(PWR_UP==TRUE)
{
* CHECK WHICH ARRAY TO COPY
IF(MSG1_RECEIVED==TRUE && COPY_OK==TRUE)
CALL COPY_BITS(SOURCE1,DEST,20)
ELSE
CALL COPY_BITS(SOURCE2,DEST,20)
* USE PREDEFINED SUBROUTINE TO EXTRACT STATION NUMBER FROM
* DEST ARRAY
CALL BIN_TO_INT(STATION, DEST[0], DEST[1], DEST[2], DEST[3])
IF(STATION==10)
BOOL STATION_10_SEND = SEND_OK * (.N.DEST[4] + VRDFRNT-DI)

Figure 8-1. Logic Programming Sample

8.2.3 Communications

See Section 8.3 for Alstom's library of communications protocols.

- Office - This provides local or interlocking information to a remote office for display while allowing the office to control routing through the interlocking.
- Remote Access Terminal
- Automatic Train Dispatch
- Platform Signs
- Intra- or Inter-system communications - Allow expansion of the system or partitioning of the non-vital subsystem into multiple processors. Also allows neighboring locations to exchange interlocking information.

8.3 SYSTEM SOFTWARE INTERFACE MATRIX

These features are available through the software items listed below, which are distributed with the CAAPE software package:

Table 8–1. Communications Protocol Library

Protocol	Part Number	Alstom Publication Number
System V (CSEX1)	51615-108-12	
System V2 (CSEX2)	51615-208-12	
System V2 (CSEX3)	51615-408-12	
Data Logger	51612-012-14	P2512E
Generic Port Interface	51612-013-04	
System Status Interface	51612-014-02	
DataTrain VIII	51612-001-18	P2346E
LCE	51612-002-08	P2346A
K\K2	51612-003-06	
DataTrain IV	51612-004-04	P2346D
SCS128	51612-005-01	
S2	51612-008-08	P2346B
Genisys	51612-009-13	P2346F
J	51612-010-05	P2346S
USS504	51612-012-02	P2346G
MCS1	51612-015-04	P2346R
MODBUS Master	51612-016-01	P2346AA
MODBUS Slave	51612-017-02	P2346AA
MARTA TWC	51612-018-01	
TEXT	51612-019-01	
USS514	51612-021-03	P2346G
SCS128DC	51612-022-01	P2346H
DataTrain II	51612-023-03	
NVTWC Taegu, Taipei, Shanghai	51612-024-02[4]	P2517A

[4] TWC hardware required (-119 series of boards).

Table 8–1. Communications Protocol Library (Cont.)

Protocol	Part Number	Alstom Publication Number
NVTWC MARTA	51612-025-01[4]	
NVTWC BART Modem	51612-026-01[4]	P2374F
NVTWC BART MUX	51612-027-01[4]	
SLP2	51612-028-02	
LDTS MARTA	51612-030	P2346AB
LDTS Taegu	51612-031-03	
CN2000	51612-032-09	P2346Q
NVTWC WMATA	51612-033-02[4]	P2346V
ARES	51612-034-07	P2346P
ARES Radio	51612-035-02	
WMATA RTU	51612-036-10	P2346T
NVTWC Seoul	51612-037-01[4]	
ATCS	51612-038-04	P2346U
OPCE Protocol	31965-015-01	P2346Y
DataTrain VIII Relay	51612-039-01	

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